AEG
Applied Energy Group

EEPS REVIEW RESEARCH REPORT

March 15, 2019

Prepared for:
HAWAII PUBLIC UTILITIES COMMISSION

Energy Solutions Delivered.

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EXECUTIVE SUMMARY

In 2008, the State of Hawaii partnered with the United State Department of Energy to establish the Hawaii Clean Energy Initiative ("HCEI"), with a goal of meeting 70% of the State's energy needs through renewable energy and energy efficiency by 2030. The Hawaii State Legislature subsequently passed Act 155, Session Laws of Hawaii 2009 (Act 155), codified under § 269-96, Hawaii Revised Statutes ("HRS"), which established the State's energy efficiency goals into an Energy Efficiency Portfolio Standard ("EEPS"). As specified in HRS § 269-96, the statewide EEPS goal is 4,300 gigawatt-hours ("GWh") of electricity savings by 2030.

This report presents the analysis that was completed by Applied Energy Group ("AEG") in support of the Hawaii Public Utilities Commission's ("Commission") Report to the 2019 Legislature on Hawaii's Energy Efficiency Portfolio Standard. The purpose of this report is to provide to the EEPS Technical Working Group ("TWG") both a historical review of prior market intervention activities and resultant EEPS savings contributions, and a preliminary forecast of economic potential energy savings through 2030. This is the first of several EEPS Review research reports that will ultimately support TWG discussion of various EEPS-related topics.

As a supporting document, some of the analysis presented in this report was also presented in the EEPS Report to Legislature, but this document also presents additional views of savings as they relate to the EEPS goals, including cumulative persisting savings, and more detail and results from the Phase I Potential Study Update.

Below we present findings from the EEPS research for context.

Interim EEPS goal achieved. The EEPS goal has proven effective at accelerating deployment of energy efficiency resources throughout the State. In accordance with HRS § 269-96, the Commission developed a framework ("EEPS Framework") to govern the achievement of the EEPS goal with four interim reporting periods, the first of which was completed in 2015.[1] The interim goal for the first reporting period is 1,375 GWh of savings. This goal was divided into annual goals of 196.5 GWh for 2009 and 2010 and 196.4 GWh for 2011 through 2015. As shown in Figure E-1, the State achieved the 2015 interim goal. The State also appears to be on track to meet the 2020 interim goal.[2]

Hawaii Energy Programs contribute a majority of EEPS savings. "Hawaii Energy" is a ratepayer-funded energy efficiency program designed and implemented by the Public Benefits Fee Administrator ("PBFA") under contract to the Commission, serving the islands of Hawaii, Maui, Lanai, Molokai, and Oahu.[3] As Figure E-1 illustrates, the incentives and services provided by Hawaii Energy Program have provided just over half of total EEPS contributions during the First EEPS Performance Period (a cumulative 1,106 GWh of 1st year savings). Figure E-2 shows that these savings represent a cumulative 80% of the interim goal for the First EEPS performance period. These savings were delivered at a cost far below the avoided cost of electricity generation.[4]

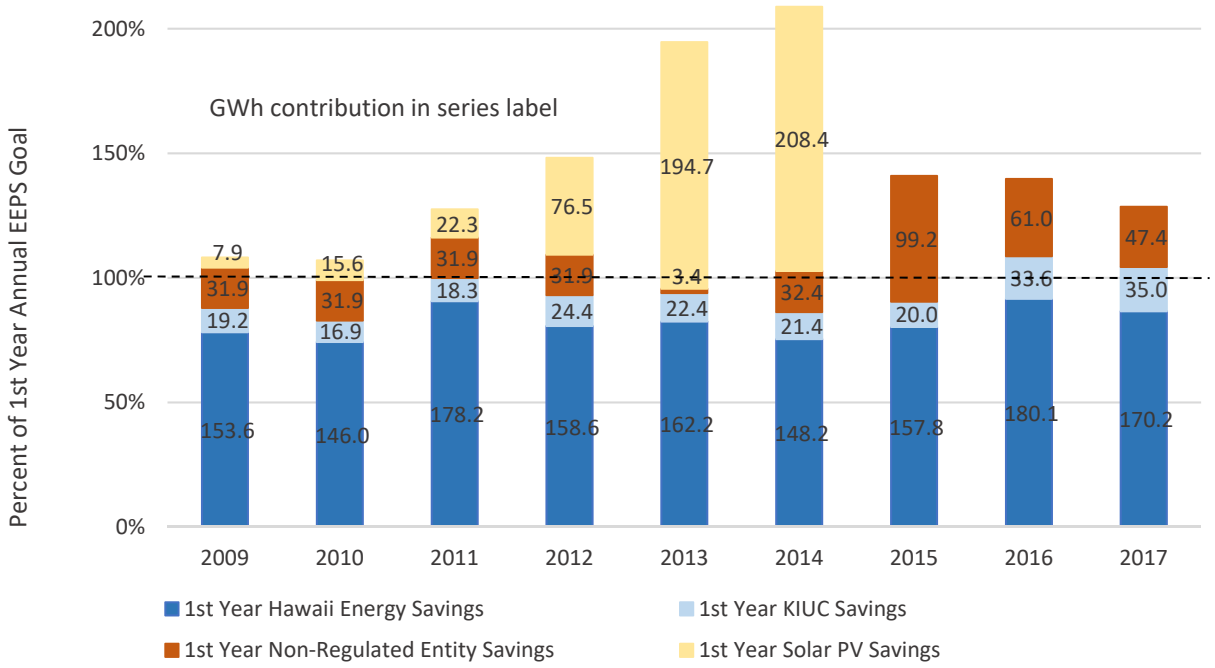
[1] The EEPS Framework was approved by the Commission in Decision and Order No. 30089, issued on January 3, 2012 in Docket No. 2010-0037.

[2] Section 2 of this Report describes uncertainty in savings estimates.

[3] Kauai Island Utility Cooperative ("KIUC") implements its own energy efficiency programs for its customers.

[4] Hoffman, Ian, *et al*. June 2018. *The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015*. Lawrence Berkeley National Laboratory.

Figure E-1 Annual 1st Year Energy Efficiency Accomplishments, Statewide



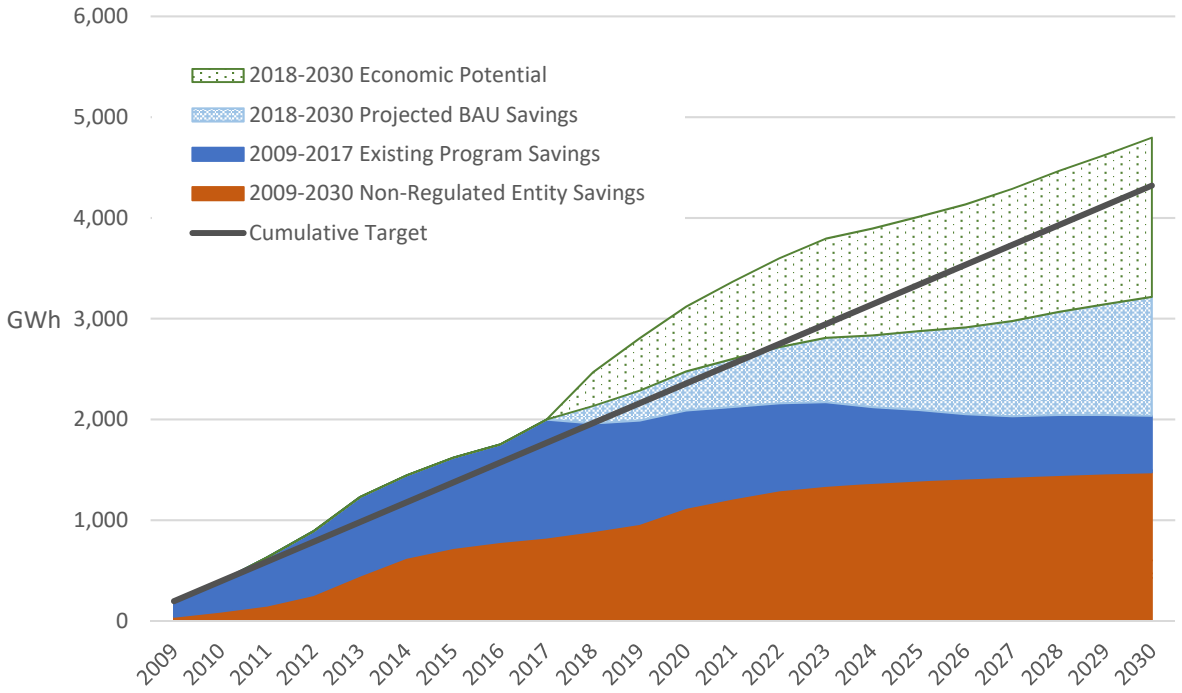
NOTE: Pursuant to HRS 269-91, solar PV savings after 2014 count towards the RPS.

Energy efficiency provides additional benefits. The Hawaii Energy Programs bring the benefits of the clean energy transformation to those customers who cannot easily otherwise participate. Hawaii Energy has successfully innovated its program strategies to provide more savings and opportunities to low-income ratepayers, renters, small businesses and other "hard-to-reach" customers using targeted incentive programs and transformational programs, which provide access to energy efficiency resources for all demographics, especially hard-to-reach communities.

Energy efficiency provides many other important benefits to Hawaii's utilities and ratepayers, including reduction in grid utilization (which reduces future utility capital and maintenance expenses for transmission and distribution assets), peak demand reduction (reduces requirements for generating capacity to serve peak load), reductions in the cost of compliance with environmental regulations, and reductions in overall electricity sales that contribute to meeting the State's Renewable Portfolio Standards ("RPS"). In addition, by targeting energy efficiency investments based on time and locational value to the grid, energy efficiency can improve the ability to integrate variable renewable resources into the existing power system.

Business as usual approach to EEPS may not be sufficient to achieve the 2030 EEPS goal. The preliminary forecast, using business as usual assumptions, shows that the EEPS program appears to be on track to meet interim goals through 2020, but not between 2020 and 2030. Phase I of the 2019 Energy Efficiency Potential Study analysis indicates that the available, untapped, economic energy efficiency resource in Hawaii exceeds the EEPS goal of a cumulative 4,300 GWh in 2030. These preliminary findings, shown below, suggest that the EEPS goal is achievable, but requires strategic adaptation, possible increases in energy efficiency program budgets, and continued innovation in program design.

Figure E-2 Energy Efficiency Potential, Statewide



A more aggressive approach is likely required to achieve the EEPS 2030 goal of a cumulative 4,300 GWh of savings. To date, Hawaii Energy has cost-effectively contributed the majority of the EEPS savings while also expanding its efforts to serve lower income and hard-to-reach customers. For example, Hawaii Energy's residential lighting program has been a big success and a dominant factor during the First EEPS Performance Period. While the savings resulting from Hawaii Energy's substantial contribution to the transformation of the lighting market will continue to count toward the EEPS goal in the form of codes and standards savings, this program success requires Hawaii Energy to rebalance its portfolio in order to maintain similar program impact levels in the future. Rebalancing with different efficiency measures are expected to increase future cost of saved energy, especially in combination with the increased emphasis on non-resource, transformation programs that address lower income and hard-to-reach customer equity.[5] Thus, the business-as-usual funding and approach to the Hawaii Energy portfolio will likely not sustain that dominant level of contributions to the EEPS goals between 2020 in 2030.[6]

[5] Despite these rising costs, the Hawaii Energy portfolio should continue to be very cost effective compared to other energy resources.

[6] Some of the shortfall depicted in the graph may be captured by future codes and standards adoptions and other market effects.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1

INTRODUCTION

In 2008, the State of Hawaii ("State") partnered with the US Department of Energy to establish the Hawaii Clean Energy Initiative (HCEI), with a goal of meeting 70% of the State's energy needs through renewable energy and energy efficiency by 2030. The goal is based on increasing the proportion of electricity generated by clean, local renewable sources instead of imported fossil fuels to 40% and reducing electricity use by 30%. Within a year, the Hawaii State Legislature ("Legislature") endorsed these policies in Act 155, Session Laws of Hawaii 2009 ("Act 155") which, among other things, revised the Renewable Portfolio Standard ("RPS") to 40% by 2030 consistent with HCEI[7] and established the State's Energy Efficiency Portfolio Standard ("EEPS"). The EEPS goal is 4,300 gigawatt-hours ("GWh") of electricity savings by 2030, although the Commission is empowered to revise the standard if needed.[8,9]

Pursuant to HRS § 269-96, the Commission opened Docket No. 2010-0037 on March 8, 2010, to establish a stakeholder-based process to develop and implement a framework for achieving the State's EEPS goal. The purpose of the EEPS Framework is to set forth principles and strategies for achieving the EEPS goal and to establish interim goals that will set the course for achieving the 2030 standard. The Commission approved the EEPS Framework in Decision and Order No. 30089 on January 3, 2012. The EEPS Framework provides broad guidance on responsibilities and roles for various entities that can contribute to meet EEPS goals, as well as setting interim goals broken out in five-year increments corresponding to the reporting periods prescribed in HRS § 269-96.

The Framework also includes guidelines on the estimation and evaluation of applicable EEPS savings. The Commission acknowledged that while the Framework is intentionally broad and flexible, it is based on information and resources available during its development (2010-2011). Evaluation of the EEPS Framework and the EEPS goals will continue and may result in modifications or adjustments to the goals, Framework, or both over time.

In keeping with language articulated in HRS § 269-96, the Framework identifies four "performance periods" during the EEPS implementation timeline (January 1, 2009-December 31, 2030) and requires five "evaluation reports." The first report was submitted to the Legislature in January 2014 to report on the development and start-up of PBFA programs and the EEPS Framework. The next four evaluation reports (reports two through five) are due to the Legislature following each of the four performance periods.

The content of this report was developed in support of the evaluation of the progress toward EEPS goals in the First EEPS Performance Period (2009 – 2015) and the associated report to Legislature.

In the remainder of this section, we present some additional background information regarding the contributions to EEPS savings, the types of savings metrics we present throughout the report, our overall approach to the research, and finally the structure of the remainder of the report.

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[7] In 2015 the Legislature enhanced the RPS even further, requiring 100% renewable generation by 2045. Hawaii is the first state to establish a 100% renewable target.

[8] Hawaii Revised Statute (HRS) § 269-96. https://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0096.htm

[9] The 4,300 GWh figure was derived by calculating 30% of the sum of the baseline electricity savings forecasts from the HECO Companies' third Integrated Resources Planning Process and KIUC's 2005 IRP with the forecast year beginning in 2008. Three potential metrics are described in the EEPS Framework. 1) 4,300 GWH, 2) 30% of forecasted energy sales in 2030 (assuming updated forecasts are used for each evaluation period), 3) energy efficiency to meet a fixed percentage of sales relative to a two-year average of total most recent statewide energy sales. See EEPS Framework for more details: http://www.hawaiicleanenergyinitiative.org/wp-content/uploads/2017/04/EE-Charrette_PUC_Decision-Order30089.pdf

Who Contributes to EEPS Savings?

While the majority of the EEPS savings has historically been provided by the Hawaii Energy portfolio, other entities can contribute to achieving the EEPS goals under the guidelines of the Framework. Below we define contributing entities as they are presented in the Framework.

The EEPS Framework names two categories of contributors to the EEPS goals: Commission Regulated Entities and Non-Regulated Entities. Each category is defined as follows in the Framework document:

- Commission Regulated Entity savings include savings utility administered and third party administered energy efficiency programs. Kauai Island Utility Cooperative ("KIUC") administers its own programs. The Hawaiian Electric Companies ("HECO") have Hawaii Energy, which is the branded name of the ratepayer-funded energy efficiency portfolio administered by the Public Benefits Fee Administrator (PBFA). The bulk of these savings are anticipated to be provided by traditional (rebate-based) energy efficiency programs administered by KIUC and the PBFA. However, savings from non-traditional utility measures such as rate design, AMI, and transmission and distribution efficiency are also eligible.[10]
- Non-Regulated Entity savings include savings from:
    - Legislative mandates. Local, state and federal agencies are subject to mandatory benchmarking which encourages investment in efficiency for all properties. Agencies with such mandates in place include the U.S. Military and the Hawaii State Energy Office ("HSEO").
    - Non-profits. Many small and large non-profits, environmental groups, and community organizations are actively working to educate citizens about energy efficiency and the education they provide may result in significant reductions in energy usage at home and in offices. An example is Aloha United Way's efforts in energy efficiency awareness.
    - Other coordinated programs. The PBFA and/or KIUC may coordinate with government agencies to assist in the design of new standards or other assistance that complement ratepayer-funded programs. The Green Energy Market Securitization ("GEMS") Financing program is an example of such a program.
    - Building codes, and federal, state, and local appliance standards. These codes and standards are also considered contributing entities. Savings from codes and standards are addressed in the next Section.

Overall Approach to the Research

Given that our goals were to quantify savings from both regulated and non-regulated entities, our research required a variety of methods. Below, we describe, at a high level, our approach to quantifying savings for the two categories of entities. More detailed descriptions of our approach to each piece of the analysis are presented in the appropriate sections of the report.

Commission Regulated entities included Hawaii Energy and KIUC:

- For our analysis related to Hawaii Energy, we reviewed publicly available documents and reports including: Annual Reports, Annual TRMs, and Annual Verification reports.
- For KIUC we conducted an interview with KIUC representatives to discuss their program savings and reviewed publicly available reports and filings.

[10] Data regarding savings from non-traditional utility measures was not captured as part of this EEPS review period due to a lack of time and resources, however, it should be noted that they could contribute a significant amount of savings during future review periods.

Non-Regulated entities included State and federal agencies, GEMS, and federal, state and local appliance standards:

- For local, state, and federal agencies and the GEMS program AEG conducted interviews with representatives of each entity to discuss their program savings and reviewed publicly available reports when appropriate.
- To estimate savings from historical and future codes and standards, AEG completed a partial update to the 2014 Potential Study, referred to as the Phase I throughout this report.

Savings in the Context of this Report

As noted above, the content of this report was developed in support of the evaluation of the progress toward EEPS goals in the First EEPS Performance Period (2009 – 2015) and the associated report to Legislature. One of the key goals of AEG's analysis was to assess progress toward the State's EEPS goal, a 4,300 GWh reduction in annual electricity consumption by 2030. Performing the assessment necessitated a comparison of savings from different sources and using different metrics. For consistency, the following definitions as they relate to savings were developed:

- 1st Year Savings. The aggregate savings from an energy efficiency measure or program intervention achieved during the 12 months following implementation.
- Cumulative Persisting Savings. The aggregate savings during a given year (the measurement year) from all previously installed measures that persist (deliver savings) in the measurement year plus the savings from measures installed in the given year.
- Lifetime Savings: The sum of annual savings delivered by a measure or program intervention over its useful life.

Note that unless otherwise stated, consistent with the EEPS Framework, all savings are presented at the system level and include savings from transmission and distribution losses, and savings from free riders and spillover. More information on various types of savings that might appear in this report or in supporting materials is included in Appendix A.

Organization of the Report

The remainder of this report is organized as follows:

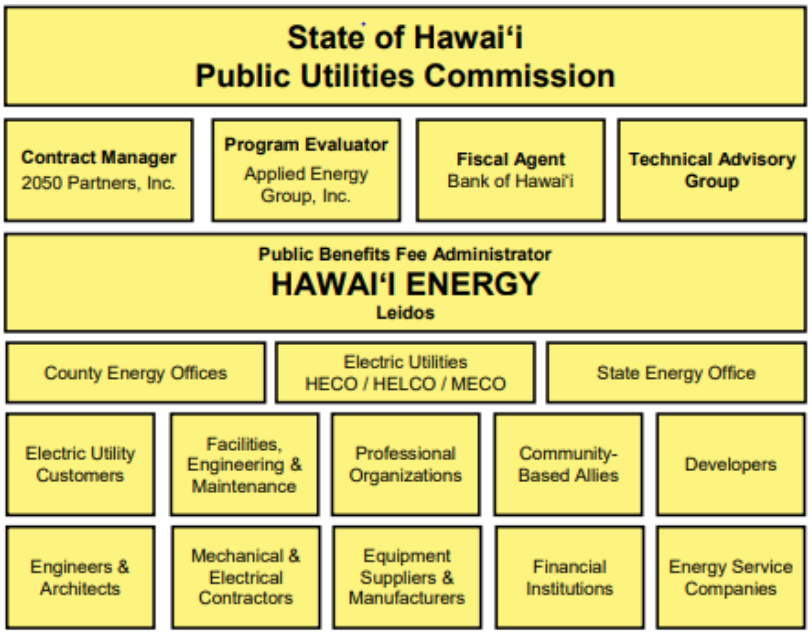
- Chapter 2: Performance of Hawaii Energy
- Chapter 3: Other Contributing Entities Research and Results
- Chapter 4: Potential Study Update
- Chapter 5: Progress Toward State Goals

2

PERFORMANCE OF HAWAII ENERGY

Hawaii Energy is the branded name of the ratepayer-funded energy efficiency portfolio administered by the Public Benefits Fee Administrator ("PBFA") under contract with the Commission. Hawaii Energy serves electric utility customers on the islands of Hawaii, Maui, Molokai, Lanai, and Oahu. KIUC currently administers its own energy efficiency program for its customers on Kauai. In the figure to the right, we present an organizational chart from Hawaii Energy's 2017 Annual Report which shows the oversight and support organizations associated with the Public Benefits Fee ("PBF").

Figure 2-1 PBF Program Oversight and Support Organizations



Hawaii Energy's programs and services are funded by a Public Benefits Fee surcharge collected through customer bills.[11] Energy savings reported through these programs developed by the PBFA are subject to verification by an independent program evaluator.[12]

Leidos Inc. serves as the current PBFA. The company is under contract with the Commission to design and implement the Hawaii Energy Program until December 31, 2019 (with a possible extension of up to six years at the discretion of the Commission). Under the PBFA contract, 70% of the PBFA budget is designated for direct incentives in the form of cash rebates or services for customers. Total administration costs including those for evaluation, measurement, and verification ("EM&V"), the PBFA Contract Manager, the Fiscal Agent, and the program finance auditor are limited to 10% of the overall budget. The remaining 20% of the budget is spent on outreach, transformational programs, supporting services, and infrastructure and facilities fees.

In this chapter, we examine the performance of Hawaii Energy during the First EEPS Performance Period (2009 – 2015) plus 2016 and 2017. We include an analysis of savings trends, costs, cost effectiveness, and equity of the portfolio.

[11] See Haw. Rev. Stat. §§ 269-121 – 269-124. See also Decision and Order No. 23258, Docket No. 05-0069, filed on February 13, 2007.

[12] See Haw. Rev. Stat. § 269-124(7).

Data Collection and Analysis Approach

Hawaii Energy achievements are, and have been, a majority contributor to the State's EEPS qualifying savings. Therefore, our analysis sought to obtain as much historical information regarding savings as possible in order to facilitate an analysis that covers the entire First EEPS Performance Period and beyond, beginning in 2009 and ending in 2017.

Below, we first describe the data sources and data collection process. Then we describe our approach to the analysis.

Data Sources

AEG used several data sources to support the analysis including publicly available reports, data transfers from Hawaii Energy, and previous databases developed by Opinion Dynamics Corporation (ODC) and subsequently updated by AEG. The data sources are as follows:

- Publicly available documents. Each of the documents below is available on the Hawaii Energy Website: https://hawaiienergy.com/about/information-reports
  - EM&V reports. Each year an independent 3rd party conducts a verification of the Hawaii Energy Programs.[13]
  - Hawaii Energy Annual Reports. Each year Hawaii Energy submits a report detailing the portfolio's achievements to the Public Utilities Commission.
  - Hawaii Energy Technical Reference Manuals ("TRMs"). TRMs provide guidance in the form of methods, formulas, algorithms, and assumptions to estimate savings from Hawaii Energy measures and projects.[14]
- Hawaii Energy 2017 verification database. Hawaii Energy provided the AEG team with customer-level data including measure and savings information on the 2017 Hawaii Energy portfolio.
- Data tracked by ODC. The previous verification contractor collected and tracked various savings and cost metrics related to the Hawaii Energy portfolio through time.

Approach to the Analysis

The analysis was approached in several steps which are described below.

- AEG's first task was to collect the data needed to provide summary data for Report to Legislature. Our initial starting point was the information developed from the 2014 EEPS Report to the Legislature which summarized the State's savings from the First EEPS Performance Period. The summary information was related to historical savings, costs, and cost effectiveness.
  - During the replication of the summary data from the 2014 EEPS Report to the Legislature, AEG identified several differences in the metrics, which were reported in various public sources. A definition of the various metrics and a description of the observed differences is presented in Appendix A.
- In conjunction with the Energy Efficiency Manager ("EEM"), AEG also developed additional levels of summary information for potential inclusion in the 2019 EEPS Report to Legislature. This information

[13] Previous third-party verifications were focused on verifying that the assumptions of the TRM were correctly applied and have not consisted of rigorous ex-post evaluation activities (such as billing analysis, engineering review, and survey verification).

[14] The TRMs are updated annually, however they are only reviewed by a third party every few years. The TRMs are currently under review by AEG.

included the identification of trends in savings, costs, and equity over time by sector, program, and end use.

- AEG examined the savings achievements of the program at various levels and using various metrics.
  - Levels included: portfolio level, sector level, end-use level, and program level
  - Metrics included: 1st year savings, lifetime savings, and cumulative persisting savings
- AEG also developed summary information around cost effectiveness at various levels including portfolio level, sector level, end-use level, and program level
- Finally, AEG gathered and summarized information regarding Hawaii Energy's island equity goals.

The resulting information and analyses are presented in the subsections that follow.

Savings from Hawaii Energy

This section describes the achievements of the Hawaii Energy Portfolio in terms of overall savings, 1st year savings, lifetime savings, savings as a percent of EEPS goals, cost effectiveness, and equity.

Overall Savings

Table 2-1 below presents total program impacts over the First EEPS Performance Period (PY2009-PY2015), as well as for program years 2016 and 2017.[15] [16] For the purposes of EEPS reporting, verified savings are presented at the system level and include avoided power station use and transmission and distribution losses. Between 2009 and 2017, Hawaii Energy has delivered nearly 1,500 GWh of 1st year savings to customers, with the most recent years, 2016 and 2017, achieving 180.1 GWh and 170.2 GWh of 1st year and 1,713.5 and 1,806.7 GWh of lifetime savings respectively. In addition, Hawaii Energy has achieved just over 1,000 GWh of cumulative persisting savings.

Table 2-1 Summary of Hawaii Energy System-Level Savings by Program Year

Program Year	Demand Reduction (MW)	1st Year (GWh)	Lifetime Savings (GWh)	Cumulative Persisting Savings (GWh)
2009	31.1	153.8	979.5	153.8
2010	23.3	146.6	1,039.0	300.8
2011	23.6	178.3	1,092.7	478.0
2012	20.7	158.5	1,109.1	633.8
2013	23.9	162.2	1,361.8	741.7
2014	26.2	148.4	1,174.7	784.8
2015	28.0	157.8	1,371.6	867.2
2016	25.7	180.1	1,713.5	944.3
2017 (reported)	25.0	170.2	1,806.6	1,064.4

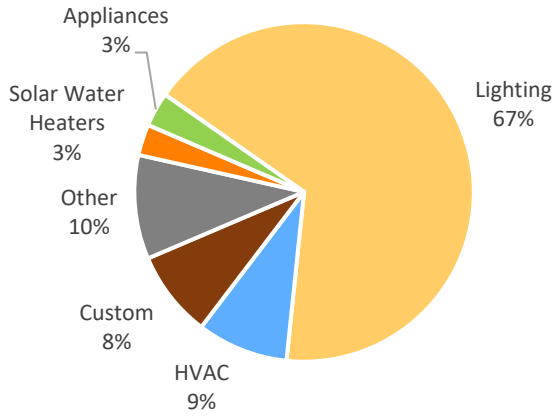
[15] Detailed Annual Reports for Hawaii Energy portfolio are online at hawaiienergy.com/about/information-reports

[16] Hawaii Energy savings are calculated using a rolling baseline which accounts for the installation of equipment and measures which are likely to have occurred absent the program in a given year. Therefore, these estimates are conservative when compared to an estimate using a 2008 baseline as suggested by the EEPS framework. For example, the current residential lighting baseline is a mix of CFLs and high efficiency bulbs, the equivalent 2008 baseline would be incandescent.

1st Year Savings

Figure 2-2 shows total 1st year savings by equipment across both the residential and commercial sectors. With over 67% of the total 1st year savings, the lighting sector has been the main driver of savings to date. The "other" category is the second largest contributor to savings and includes Hawaii Energy's Peer Group Comparison reports program.[17] Heating, ventilation and air conditioning ("HVAC") measures contribute close to 10% of the savings while custom programs, appliances, and solar water heaters contribute less than 10% each.

Figure 2-2 Sum of 1st Year Savings by Equipment



Hawaii Energy has intentionally concentrated on supporting the transformation of the lighting market and has been very successful in achieving those savings. Over time, as the residential general service lamp market has been successfully saturated, the portfolio lighting savings shifted from the residential sector, where CFLs and LEDs were installed more readily, to the business sector where there is more remaining opportunity.

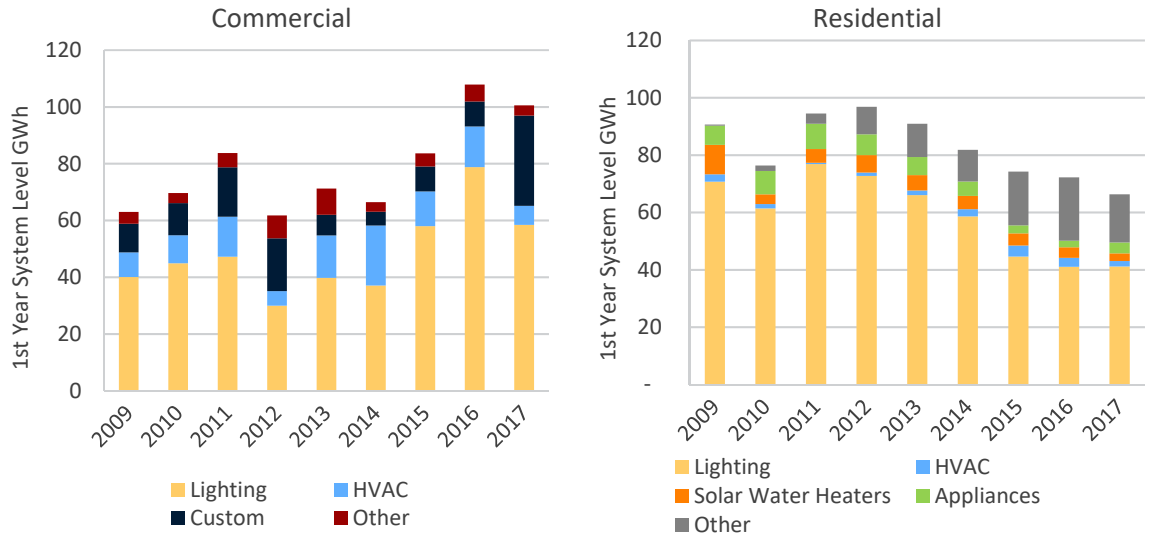
This transition from residential- to commercial-dominated savings is illustrated in Figure 2-3 below. The figure shows the total system level 1st year savings by year; the percentage attributable to the commercial sector is shown in orange, and the percentage attributable to the residential sector is shown in teal. In 2009, the residential sector accounted for 59% of the savings while the commercial sector accounted for 41%. The residential sector continued to achieve most savings until 2015. In the last two years, the commercial sector accounted for 60% of the savings while the residential sector accounted for 40%.

Figure 2-3 1st Year System Level Savings by Sector Over Time

[17] Peer Group Comparison Reports is the name for Hawaii Energy's home energy report behavioral program.

In Figure 2-4, 1st year program savings are shown by sector and end use. As noted above, lighting savings dominate the Hawaii Energy portfolio. Lighting savings in the commercial sector increased substantially in recent program years relative to previous years through a focus on upstream programs, energy efficiency incentives, and small business direct install. Conversely, residential lighting savings from programs have been falling over time as lighting savings shift from being incentive-driven through the Hawaii Energy portfolio, into savings from federal codes and standards. As residential lighting savings have dropped, Peer Group Comparison report savings have made up some of the difference (shown here in the "other" category) reaching over 230,000 customers, nearly all eligible households, in Hawaii, Honolulu, and Maui counties in 2017 from its modest start.

Figure 2-4 Sector Level Contribution to 1st Year System Level Savings by End Use[18]



Cumulative Persisting Savings

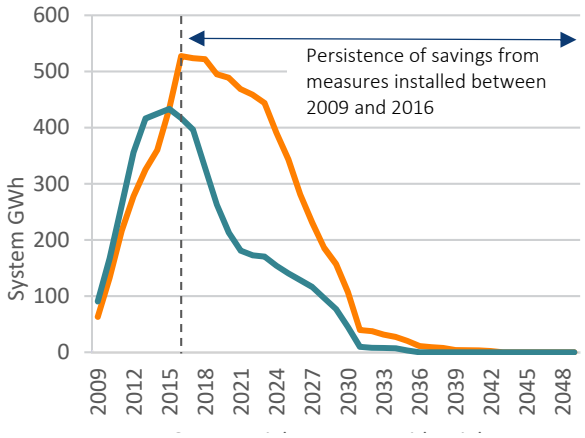
While much of the previous savings were expressed as 1st year savings, we now shift our focus to cumulative persisting savings, which account for measure life and illustrates the projected impact of savings achieved up to 2016, through 2048[19]. Recall from Section 1, above, that cumulative persisting savings represents the aggregate savings during a given year from all previously installed measures that still deliver savings, plus the savings from measures installed in the given year. Further, each measure has a defined useful life associated with it; savings from installed measures are assumed to go away once the useful life of the measure ends. For example, the useful life of an LED light bulb is 15 years. In this case, the savings would persist for 15 years after installation, then disappear when that bulb reached the end of its useful life. In this view of savings, we do not assess savings from market transformation or codes and standards (e.g., future purchase decisions of participants) when a program LED is replaced at the end of 15 years with a new lamp that may or may not be efficient.

[18] Residential "other" is significantly driven by Peer Group Comparison Reports while Commercial "other" is a mix of various measures, such as variable frequency drives, premium efficiency motors, and high efficiency water heat, that don't fit in one of the main categories.

[19] Lifetime savings only include savings from program interventions occurring in years 2009 through 2016. While the 2017 first year savings and total lifetime savings were available, the year-by-year 2017 lifetime savings trajectories were not available at the time this report was completed.

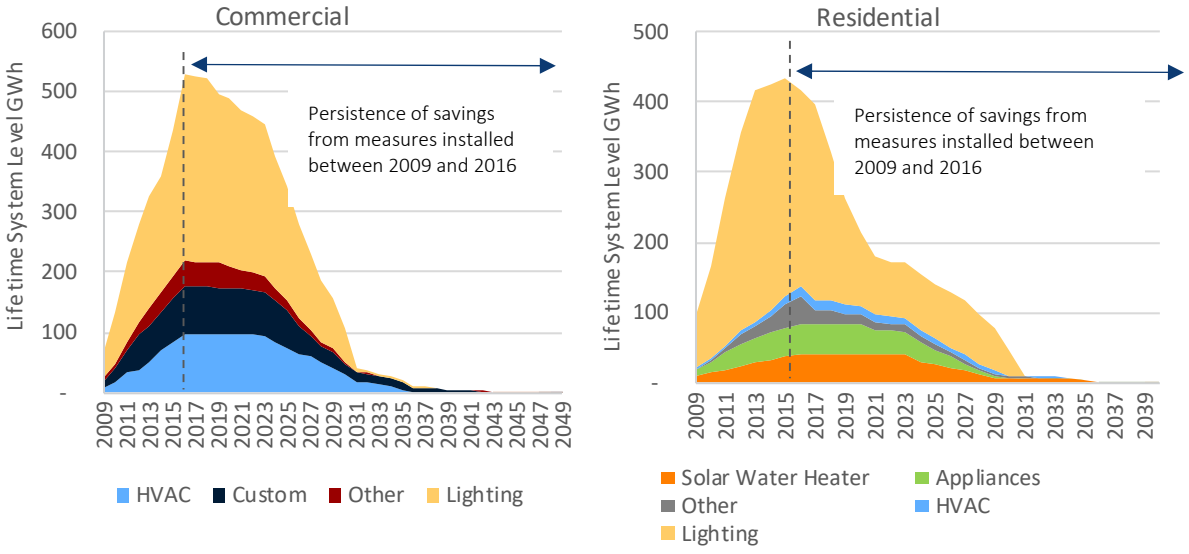
In Figure 2-5, we show the total cumulative persisting savings attributable to both the commercial and residential sectors for program activities through 2016. Commercial is again shown in orange, and residential in dark teal. The vertical dashed line represents the last year of program savings included in the series. Note that commercial savings are both larger and longer lasting than residential savings due to the fact that the commercial measures tend to have a longer useful life.

Figure 2-5 Cumulative Persisting Savings by Sector



In Figure 2-6, cumulative persisting savings are further broken out by sector and equipment. In this figure, it is clear that the commercial lighting measures have a longer life than the residential lighting measures, driving the differences in Figure 2-5. Furthermore, the Peer Comparison Reports, in grey, only have a one-year measure life since there is still some uncertainty within the industry regarding the persistence of behavioral savings. Savings from Custom, HVAC, and residential appliances have significantly longer measure lives.

Figure 2-6 Cumulative Persisting Savings by Sector and Equipment



Hawaii Energy Savings as a Percentage of EEPS Goal

Hawaii Energy has been, and continues to be, a large contributor to the EEPS goal accounting for 80% of the annual goal in year 2015 (the end of the First EEPS Performance Period) and 87% of the annual goal in year 2017 (most recent program year data). Table 2-2 presents Hawaii Energy 1st year savings as a percent of the annual EEPS goal over time. From a high level, the contribution of Hawaii Energy savings to the annual goals represents between 75% and 92% of the goal each year.

Table 2-2 Hawaii Energy Savings by Program Year as percent of Annual EEPS Goal [20]

Year	Annual EEPS Goal	1st Year Savings as a % of Annual EEPS Goal
2009	196.5	78%
2010	196.5	75%
2011	196.4	91%
2012	196.4	81%
2013	196.4	82%
2014	196.4	76%
2015	196.4	80%
2016	195.0	92%
2017	195.0	87%

Cost Effectiveness of Hawaii Energy

The Hawaii Energy Program continues to be a very cost-effective energy resource in Hawaii. The Hawaii Energy Program costs are a fraction of electricity prices in Hawaii. Hawaii Energy's direct program expenditures have maintained a lifetime energy savings cost effectiveness since 2013 of between 1.8 and 3.2 cents/kWh, a fraction of the avoided cost of energy supply. Including costs borne by program participants, the lifetime cost of saved energy is estimated to be approximately 7-8 cents/kWh.[21] This cost is well below the "wholesale" cost of electricity in Hawaii, including recent power purchase agreements for utility-scale solar PV, and compares very favorably to average retail rates, which ranged from 26 to 33 cents/kWh during the same period.[22]

Overall Costs

Table 2-3 below shows the total annual Hawaii Energy expenditures for the First EEPS Performance Period and program years 2016 and 2017. A peak annual Hawaii Energy funding level of almost $37 million was reached in program year 2015. In order to reduce customer bill increases from the newly-created GEMS program, the PBF collections, which provide funding for Hawaii Energy, were reduced substantially beginning in program year 2016[23]. Hawaii Energy adjusted its overall approach with "Hawaii Energy 2.0", including reduced incentive levels on a variety of measures and increased focus on mid-stream and upstream program delivery and other program strategies to achieve more savings with less funding.

[20] Note that program years do not align with the annual goals on a calendar basis. Program years run from July through June, while calendar years run from January through December. However, given that the annual goals are straight line goals, the comparison is appropriate given that both the program year and the annual goal cover twelve months. In 2030, an additional true-up will be required to capture savings that occurred in the last half of calendar year 2030 but would not have been included in PY2029 savings.

[21] Hoffman, Ian, *et al*. June 2018. *The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015*. Lawrence Berkeley National Laboratory.

[22] https://files.hawaii.gov/dbedt/economic/data_reports/energy-trends/Monthly_Energy_Data.xlsx

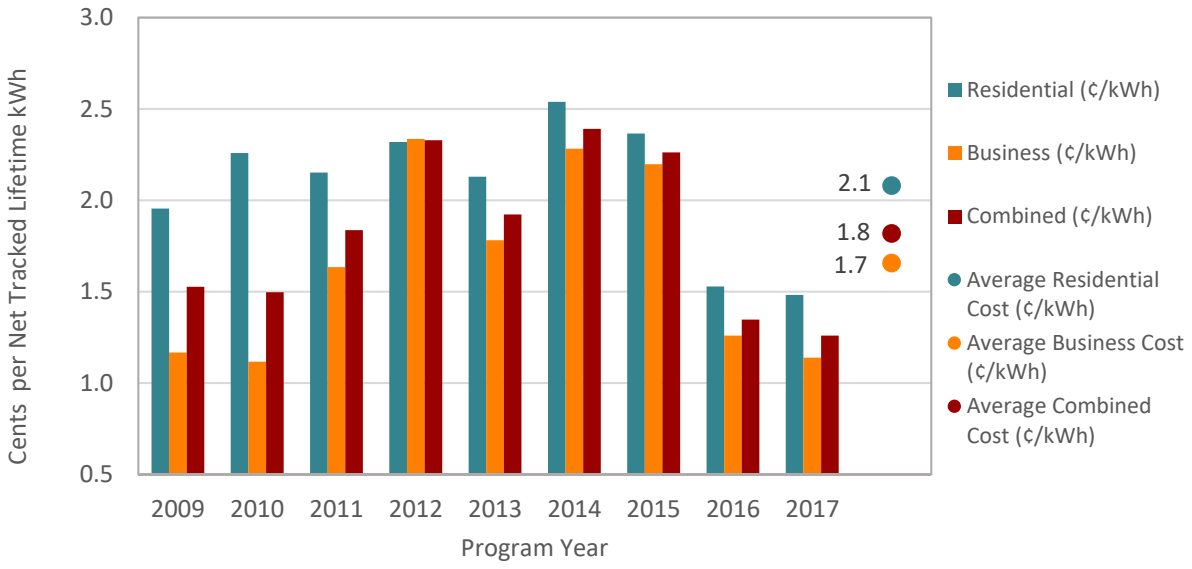
[23] The GEMS Program is the State of Hawaii's green infrastructure financing program designed to make clean energy improvements affordable and accessible for a broader cross-section of Hawaii's ratepayers. http://gems.hawaii.gov/learn-more/faqs/

Table 2-3 Summary of Hawaii Energy Expenditures and Costs

Program Year	Total Program Administration and Expenditures ($M)	1st Year Cost of Saved Energy (cents / kWh)	Lifetime Cost of Saved Energy (cents / kWh)	Lifetime Customer (Participant) Bill Savings ($M)
2009	$18.2	11.8	1.5	$255
2010	$20.1	13.7	1.8	$473
2011	$27.3	15.3	2.5	$408
2012	$32.8	20.7	3.1	$405
2013	$32.0	19.7	1.8	$517
2014	$36.0	24.3	2.4	$436
2015	$36.9	23.4	2.2	$332
Subtotal / Average	**$203.30**	**18.4**	**2.2**	**$2,826**
2016	$29.5	16.4	1.3	$441
2017	$28.7	16.9	1.3	$488
Total / Average	**$261.5**	**18.0**	**2.0**	**$3,755**

Figure 2-7 shows total program year spending per lifetime kWh saved for each program year by sector and for the overall portfolio. In the early program years, residential costs were quite low, near one cent, while the commercial costs were a bit higher at just over two cents. Between program years 2011 and 2015, residential costs increased significantly although they remained lower than the commercial costs as Hawaii Energy focused on penetrating the market with high-efficiency lighting technologies. In the most recent couple of years, residential and commercial costs fell as the portfolio shifted to LED lamps and other high-efficiency, long-life, lighting measures. Cost reductions in LED lamps and fixtures have been significant and larger than anticipated.

Figure 2-7 Overall Residential Spending vs. Savings by Program



Residential Programs and Costs

Now we look more closely at the residential costs over time[24]. In Figure 2-8 we show the residential costs per lifetime kWh saved by program year and by end use. The average cost of the "other" category is significantly higher than any other end-use because it includes the cost of the Peer Comparison Reports. These are cost effective on a 1st year basis but are more expensive relative to other measures on a lifetime basis, because the reports assume only a one-year measure life. This is likely to be an important consideration going forward as the portfolio evolves.

Figure 2-9 presents the total percent of portfolio spending and the accompanying percent of portfolio savings by program between 2009 and 2017. Accompanying Table 2-4 provides a brief summary of the residential programs for reference. The vast majority of both the spending and savings are concentrated in the Residential Energy Efficiency Measures (REEM) program with about 89% of total portfolio spend and 97% of total portfolio savings across the seven program years shown. Other programs also have similar levels of spending and savings, except for the Residential Hard-to-reach ("RHTR") program. RHTR had higher levels of spending, about 8%, and lower savings, about 1.5%. These higher levels of spending are expected in a program designed to bring energy savings to the hardest to reach parts of the population.

Figure 2-8 Residential Lifetime Cost by End Use

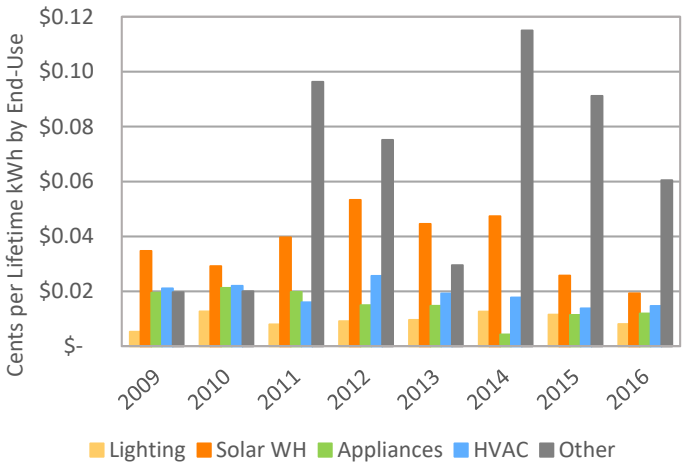
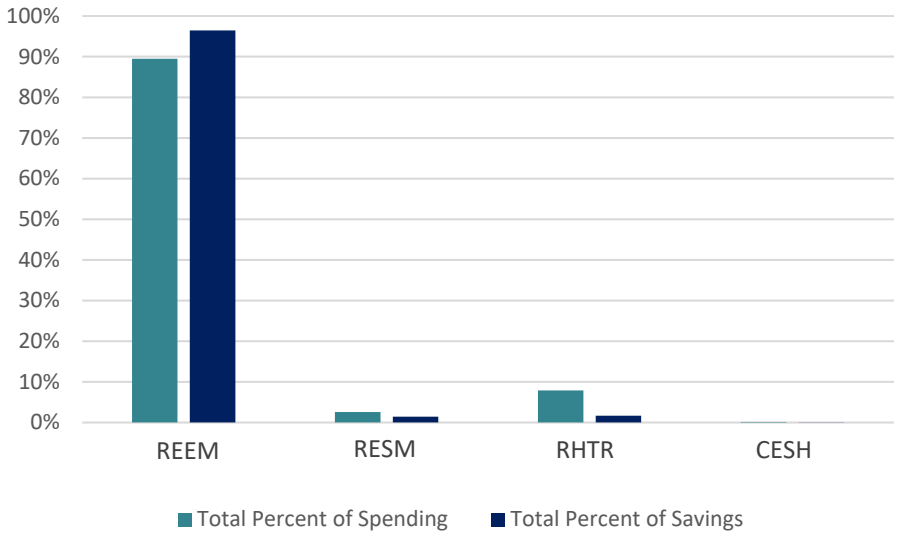


Figure 2-9 Overall Residential Spending vs. Savings by Program



[24] 2017 spending by end-use data had not been compiled at the time this report was completed.

Table 2-4 Summary of Hawaii Energy Residential Programs

Program	Objective	Actions /Measures
Residential Energy Efficiency Measures ("REEM")	This program represents the largest program within Hawaii Energy's residential portfolio, both in terms of incentives distributed and energy savings achieved.	•High Efficiency Water Heating •High Efficiency Lighting •High Efficiency Air Conditioning •High Efficiency Appliances •Energy Awareness, Measurement and Controls Systems
Residential Energy Services and Maintenance ("RESM")	Provide customers with incentives for services and maintenance to their homes' biggest energy consuming equipment.	Offerings to enhance energy savings persistence and bootstrap fledgling energy services businesses.
Residential Hard-to-reach ("RHTR")	Secure various projects among Hawaii residents that have traditionally been underserved.	Address landlord/tenant barriers through direct installation of energy saving technologies.
Custom Energy Solutions for the Home ("CESH")[25]	Provide additional flexibility to account for unforeseen market opportunities.	Residential Lighting and Central Air Conditioning upgrades.

Commercial Costs

Next, we turn to the commercial costs over time. In Figure 2-10 we show the commercial costs per lifetime kWh saved by program year and by end use. Across all years and end-uses the costs have been relatively consistent. The key exceptions include the other[26] category in 2012 and 2014, and the custom category in 2014.

Figure 2-10 Commercial Lifetime Cost by End Use

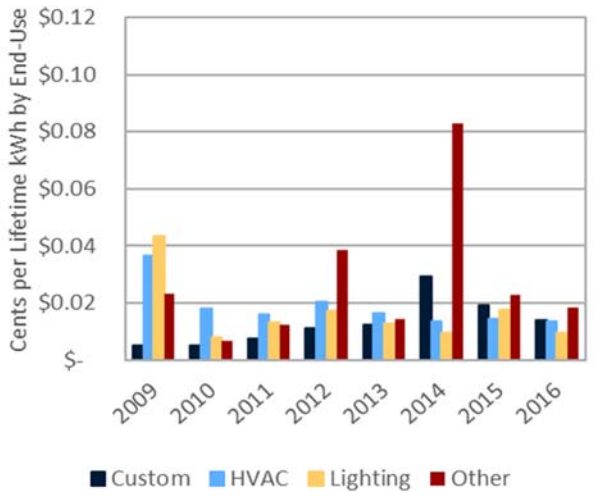


Figure 2-11 presents the total percent of portfolio spending and the accompanying percent of portfolio savings by program from 2009 to 2017. In the commercial sector, the spending and savings are spread more evenly across the different programs. The two largest contributors, both from a spending and savings perspective are the Business Energy Efficiency Measures ("BEEM") and Custom Business Energy Efficiency Measures ("CBEEM") programs. Both programs have spending in the 35 to 40 percent range and have savings that tend to have a slightly higher contribution to the total than the spending. Like with the residential programs,

[25] CESH was offered from 2010 through 2016, a new similar program was offered in 2017.

[26] Other is a mix of various measures that do not fit in one of the main categories. It includes measures such as variable frequency drives, premium efficiency motors, and high efficiency water heaters. In 2014, Hawaii Energy launched the Energy Efficiency Auction program, which included some more expensive measures such as smart thermostats and plug load devices, resulting in costs that were higher than in other years.

the Business Hard-to-reach ("BHTR") program tends to have a higher proportion of spending vs. saving, as does the Business Energy Services and Maintenance ("BESM") program which focuses on education of and collaboration with trade allies.

Figure 2-11 Overall Commercial Spending vs. Savings by Program

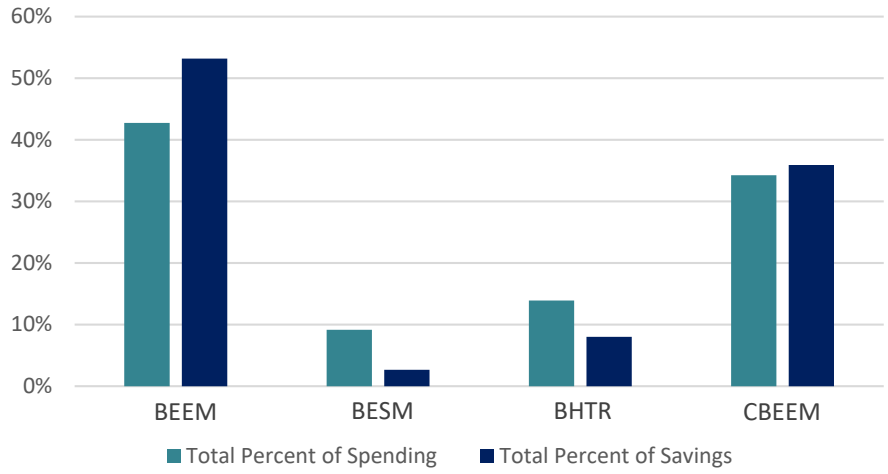


Table 2-5 Summary of Hawaii Energy Commercial Programs

Program	Objective	Actions /Measures
Business Energy Efficiency Measures (BEEM)	Acquire electric energy and demand savings through customer installations of standard, known, energy efficiency technologies by applying prescriptive incentives in a streamlined application process.	•High Efficiency Lighting •High Efficiency HVAC •Premium Efficiency Motors •High Efficiency Water Heating •Variable Frequency Drives (VFDs) •Envelope Improvements •Scheduling and Control Systems •HVAC systems such as Water-cooled chillers, variable refrigerant flow (VRF), packaged & split system, and Energy Star window A/Cs •Window Tinting. •Refrigeration Improvements
Business Energy Services and Maintenance (BESM)	Focuses on developing viable projects through collaboration, competition and direct support in the form of expertise and/or equipment (i.e., metering).	•Central Chiller Plant benchmarking program to improve chiller plan operations; •Strategic Energy Management projects; •Water and wastewater projects for energy and water savings.
Business Hard-to-reach (BHTR)	Help goaled geographic areas and sectors that have been traditionally underserved, such as retail, restaurants other small businesses and commercially metered multifamily.	•Outreach to lighting and electrical contractors with training; •Kitchen equipment and demand controlled ventilation; •Commercially metered multifamily direct install; •Small business direct install
Customized Business Energy Efficiency Measures (CBEEM)	Provide a custom application and approval process for participants to receive incentives for installing non-standard energy efficiency technologies.	•VFDs for cooling towers •Air conditioning system upgraders •Process heat recovery •LED lighting etc.

Island Equity and Hard-to-reach Programs

In Program Years 2009 through 2017, Hawaii Energy was measured against an island equity goal which is intended to promote equitable participation in the program among the counties. For years 2009 to 2012, the goal was to create direct customer energy savings within 20% of the proportion of each county's total contribution to the PBF.[27] In 2013, the goal shifted to a goal that for every dollar contributed to the PBF, a dollar would be returned to its county of origin through rebates, or other program initiatives.[28] Hawaii Energy has successfully met its island equity goals in each program year.

In addition to achieving goals related to island equity, Hawaii Energy also strives to achieve equity across all residents by increasing service to lower income and hard-to-reach customers. Hawaii Energy's direct install programs address some participation barriers for hard-to-reach customer segments by providing a simplified offering through free direct installation of energy and water saving measures. The Small Business Direct Install program began in 2011, has grown over time, and has expanded to include contractor technical training and professional development. Hawaii Energy reported that it helped over 750 under-served small businesses with its direct install lighting program in 2017. This impact is estimated to provide customer savings of over 123,083 Megawatt hours ("MWh") during the life of the lighting system and at least $28,000,000 in lifetime utility bill savings for these businesses. In 2018, the Program was renamed "Energy Advantage". The Energy Advantage program also helped with rapid response to deliver energy efficiency when Hawaii Island lost renewable generation from Puna Geothermal Venture power plant due to the eruption of the Kilauea volcano. Hawaii Energy provided Big Island businesses and residents with increased incentives, discounts, and rebates on energy efficiency measures to assist during a time when air quality was affected and use of air conditioners and purifiers escalated.

The Multifamily Direct Install program, now known as "Energy Smart 4 Homes," was launched in 2014 as a part of Hawaii Energy's continued efforts to make simple energy-efficient products readily accessible to residential utility customers. This program successful supported the retrofit of over 1,000 rental units owned by the City and County of Honolulu, a large portion of the State of Hawaii Public Housing Authority rental properties, and units managed by Catholic Charities. Direct install program integration in the community has facilitated new services to low income and hard-to-reach customers with initiatives including Molokai's "Hui Up!" refrigerator replacement drives and several new transformational programs.

[27] Hawaii Energy Annual Reports 2009 to 2012

[28] Hawaii Energy Annual Reports 2013 to 2016

3

OTHER CONTRIBUTING ENTITY RESEARCH

In this section, we present our research approach, results, and savings estimates for the "other" contributing entities listed in Table 3-1. We exclude Hawaii Energy and codes and standards since they are covered in depth in Section 2 and Section 4 respectively.

It is important to note that the savings from these other contributing entities currently account for a small portion of the EEPS goals. In addition, for the non-regulated entities, it is difficult to collect information regarding energy savings since they are not subject to regulations which require rigorous data collection and reporting. Consequently, we have lower confidence in the savings estimates that we collected from the non-regulated other contributing entities.

Table 3-1 List of Other Contributing Entities

Framework Category	Entity Group	Specific Entity or Department
Regulated Entity	Utility	KIUC
Coordinated Programs	County	Kauai County
		County of Maui
		City and County of Honolulu
		County of Hawaii
	State Program	GEMS
Mandates / Benchmarking	State Energy Office	HSEO
	University	University of Hawaii
	US Department of Defense	Hunts Companies
		Tripler Army Medical
		Marine Corps Base
		MCBH Housing Hunts Co
		Joint Base Housing - Lendlease
		Military Housing Island Palm
		US Army
		Pearl Harbor - Hickam

Approach to the Research

Since most of the entities listed above are not required to report or track energy savings in a public forum, AEG developed an interview-based data collection protocol which allowed us to collect information from each entity regarding the following aspects of energy saving projects:

- The type number, and/or other information regarding any energy saving projects that have been completed since 2014
    - If any energy saving project were completed, AEG then asked if these projects were part of a Hawaii Energy Program (e.g., received rebates, incentives, etc. from Hawaii Energy) to determine the level of potential overlap with previously reported savings.
- AEG also asked interviewees at the various entities about the following specific characteristics of each their energy savings projects:
    - Replacement/upgrades of equipment
    - Purchased new energy use equipment
    - Lighting retrofits
    - Purchased/replaced automated controls or devices
    - Made any changes/improvements to the building shell
    - Implemented any behavioral programs (e.g., encouraging employees to turn off lights and electronics when not in use)
    - Installed solar or other renewable energy
    - Purchased or leased batteries
- Finally, AEG requested any estimates of savings related to the energy saving projects that they various entities completed since 2014 and the year in which they were counted.

Results of the Other Contributing Entity Research

Below we present some high-level takeaways from the other contributing entity research. In the subsections that follow we summarize the responses and present the estimates of savings.

- AEG received an excellent response to our data collection outreach.
- Each of the entities that we spoke with is completing multiple energy saving projects.
- There is a very high level of coordination with Hawaii Energy. Most of the entities have worked with Hawaii Energy to receive the appropriate incentives and rebates for their projects. Consequently, there is also a high level of overlap between the Hawaii Energy savings and contributing entity savings.
- Most non-regulated entities track energy savings using a baseline approach, where they track changes in total energy consumption over time compared to a specific baseline year. This makes it difficult to attribute changes to energy saving projects since other factors (i.e. changes in occupancy, weather, or installation of solar PV) can also materially change total energy consumption over time.
- Of all the contributing entities we spoke with, only KIUC savings materially contribute to the total savings. This is primarily because they 1) have no overlap with Hawaii Energy, and 2) because they publicly tack their energy savings in annual kWh approach (as opposed to a baseline approach).

Summary of Responses

AEG contacted a total of eighteen different entities, completed eleven interviews, and obtained savings data (either publicly available or provided via the interview) for five entities. For the remaining six interviewees, either data was not tracked, or was not available for our review. We were not able to schedule interviews with seven of the original eighteen entities.

In Table 3-2 below we summarize the survey responses of the eleven interviewees. We include the name of the entity; whether we were able to count their savings toward the EEPS goal; the reason why, or why not the savings were counted; and a description of their energy savings projects.

Table 3-2 Summary of Responses Collected from Other Contributing Entities

Entity	Level of Overlap with Regulated Entities	Description
KIUC	No overlap with other programs	KIUC offers a full suite of energy efficiency programs and savings measures. Energy efficiency technologies include heat pump water heating, ice storage, ratepayer-funded energy efficiency programs, and use of rejected heat from co-generation and combined heat and power systems, excluding fossil-fueled qualifying facilities that sell electricity to electric utility companies and central station power projects.
Kauai County	Most savings captured by KIUC	The County of Kauai has completed several energy efficiency projects over the past several years including the installation of new more efficiency chillers and a streetlighting project. The majority of their projects were completed with KIUC.
County of Maui	Cannot verify savings outside of Hawaii Energy	Several large projects were completed with the Parks, and the Department of public works, all of these larger projects went through Hawaii Energy. In addition, they make it a practice to replace older equipment (i.e. office equipment and lighting) with more efficient versions. It is unknown how much of these more general equipment upgrades could have been rebated by Hawaii Energy.
City and County Honolulu	Most savings captured by Hawaii Energy	Most of their projects were completed for Department of Environmental Services Wastewater Facilities. They are also currently working with Hawaii Energy to complete 55,000 LED streetlight retrofits.
County of Hawaii	Lighting savings likely captured by Hawaii Energy	Replaced 11,000 streetlights with LEDs in 2014. Is currently working with Hawaii Energy to quantify the County's energy use and identify opportunities for savings.
GEMS	Only keep track of dollars saved	EE programs started in 2017, and all programs are reported by Hawaii Energy.
HSEO	Most savings captured by Hawaii Energy and Codes and Standards	Much of their work is related to quantifying the effects of codes and standards. In addition, they also coordinate the Hawaii Green Business Program and provide Energy Savings Performance Contracting technical assistance to state agencies and the counties.
Hunts Companies	Most savings captured by Hawaii Energy	Hunts Companies have participated in many Hawaii Energy Programs including AC retrofits, Energy Scout, LED controls, and solar water heaters. They have also installed lock out programmable thermostats in all housing (temp can go below 72 degrees) but they do not know the savings attribution.
Tripler Army Medical	Did not complete any projects with Hawaii Energy	Tripler replaced a number of aging air handlers and their cooling towers in 2015. All projects that include lighting are moving to LED. Building 40 has been fully renovated with a new central utility plant, HVAC equipment, water heating, solar, LED lighting, etc. There are signs around the hospital to encourage the reduction in energy consumption such as turning off lights. In newer areas LED lighting with digital controls occupancy times and sensors are being used.
Joint Base Housing - Lendlease	Cannot verify savings outside of Hawaii Energy	Hickam housing community LED replacements through Hawaii Energy. Other one-off improvements. One behavioral change is that they now make residences pay for their own energy. This has reduced electric use by 10%
US Army	Cannot verify savings outside of Hawaii Energy	The Army has completed many large projects, but they do not complete any projects without Hawaii Energy. They also have a behavioral training program which educated and audits soldiers to ensure they are following EE positive behaviors. Unfortunately, they have not attempted to quantify the savings.

Estimates of Savings

Based on the table above, we were only able to include savings for KIUC, and Tripler Army Medical. Each of the other entities either did not track savings or coordinated with regulated entities to an extent that the majority of the savings is already captured. Below we include a summary of the annual savings estimates for KIUC and Tripler Army Medical.

Table 3-3 Summary of Other Contributing Entity 1st Year Savings

Year	KIUC Savings (GWh) [29]	Tripler Savings (GWh) [30]
2009	19.2	
2010	16.9	
2011	18.3	
2012	24.4	
2013	22.4	
2014	21.4	0.87
2015	20.0	0.87
2016	33.6	0.87
2017	35.0	0.87
Total 1st Year Savings	**211.0**	**3.48**

[29] Pursuant to HRS Section 269-91, under the definition of "Renewable electrical energy," KIUC energy savings include energy efficiency technologies including heat pump water heating, ice storage, ratepayer-funded energy efficiency programs, and use of rejected heat from co-generation and combined heat and power systems, excluding fossil-fueled qualifying facilities that sell electricity to electric utility companies and central station power projects. https://puc.hawaii.gov/wp-content/uploads/2018/04/RPS-KIUC-2017.pdf

[30] Tripler savings are based on a 2014 baseline method which estimates savings as a total change from 2014. Individual annual savings estimates were not available, therefore total estimated savings is spread evenly across the total timeframe.

4

2019 POTENTIAL STUDY PHASE I

The Commission requires accurate information about the potential for future electricity savings from both programmatic and non-programmatic sources, and the associated costs, on an ongoing basis in order to design effective energy efficiency programs and to efficiently allocate expenditures towards meeting EEPS Goals. To this end, the EEPS Framework stipulates that energy efficiency potential studies for all electric utility service territories be conducted for EEPS planning purposes.

The first statewide Energy Efficiency Potential Study (2014 Study) was completed in 2014[31,32] and the results were summarized in the 2014 Report to the Legislature. It assessed the short-, mid-, and long-term achievable market potential for cost-effective energy efficiency. This potential implicitly includes the contributions of both regulated and non-regulated entities. The results of the 2014 Study provided information for program implementers to better target energy efficiency services (including those of Hawaii Energy, KIUC, and other contributing entities). It also provided analyses that could be utilized by the electric utilities in future integrated resource planning processes to identify and characterize energy efficiency resources available within their respective service territories.

Approach to the Phase I Potential Study

The current EEPS review process includes a full updating of the 2014 Study which is being conducted in two stages.

- Phase I is a partial update intended to inform this report and provide guidance for the second stage. Phase I was completed in November 2018 and is described in this section.
- Phase II will be a comprehensive update of the potential study. It will rely on an updated Baseline Study that is currently being conducted by the EEPS EM&V Consultant and will be completed in Q2 of 2019. Phase II will be conducted in the second half of 2019.

The objectives for Phase I were to estimate the historical savings from state and federal codes and standards, to align with the previous and current programmatic achievements of Hawaii Energy and KIUC and historical PV installations, and to offer preliminary insights into the potential for future savings. Because of time constraints, and because a comprehensive update in conjunction with the 2019 Baseline Study will be performed in 2019, only a limited set of changes were made to the 2014 Study.[33]

Phase I involved two steps. The first step was to align the modeling with historical trends in electricity sales, PV installations, and programmatic achievements as follows:

- Aligning with historical statewide electricity sales for 2012 through 2017 involved updating customer growth and other demographic variables to reflect actual values provided by HECO's load forecasting group.
- Adjustments were made to account for Solar PV installations from 2010 through 2014. Customer sited solar effects were estimated using data provided by HECO. HECO tracks cumulative installed kW

[31] http://www.hawaiicleanenergyinitiative.org/wp-content/uploads/2017/03/EE-Charrette_PUC_2014_Rpt.pdf

[32] The 2014 Energy Efficiency Potential Study (2014 Study) used the 2012 Baseline Study as its foundation.

[33] The Phase I update used a simplified approach based on extrapolating data from the island of Oahu and estimated historical savings from codes and standards.

capacity[34] which is multiplied by monthly capacity factors and adjusted to reflect annual degradation of PV production.[35]

- Historical (2009 – 2017) program savings for Hawaii Energy and KIUC were integrated within the model.

Once the model was aligned with known historical trends which depict actual usage, an estimate of load absent the effect of existing state and federal codes and standards was generated for the same time period (2012 – 2017). The difference between this estimate (or reference case) and the actual observed load represents our estimate of the savings resulting from state and federal codes and standards that were implemented between 2013 and 2017. Historical codes and standards prior to 2013 (2009 to 2012)[36] were taken as given based on the estimates developed for the 2014 report to the legislature.

In the second step, the updated analysis was further refined:

- Updated savings, cost and lifetime assumptions for LED lighting were incorporated. This technology evolved more quickly than the previous study (and the industry in general) anticipated.
- HECO's forecast of future solar PV installation was included.
- Future program activity that aligns with the recent program savings was assumed. This is referred to as a business-as-usual (BAU) case.

Overall Results

The updated potential analysis provides estimates of the savings from state and federal codes and standards for the historical period, 2013-2017. It also estimates 1st year (or incremental) savings, as well as cumulative persisting savings, for the forecast period (2018-2030).

Savings from Codes and Standards for 2013-2017

Figure 4-1 shows the estimated savings from building codes and equipment standards. The primary driver for these savings is the first phase of the federal lighting standard included in the Energy Information and Security Act ("EISA") which increased the efficiency of general service lighting significantly. The majority of the remaining savings came from federal appliance standards including refrigerators, water heaters, and other white goods appliances. In addition, Hawaii has a water heating standard that requires the installation of solar water heating in new construction. In 2015, savings from these standards accounted for approximately one-third of total savings toward the annual EEPS goal. It should also be noted that savings from customer-sited PV were significant in the years 2013 and 2014, accounting for more than half of the total savings.[37]

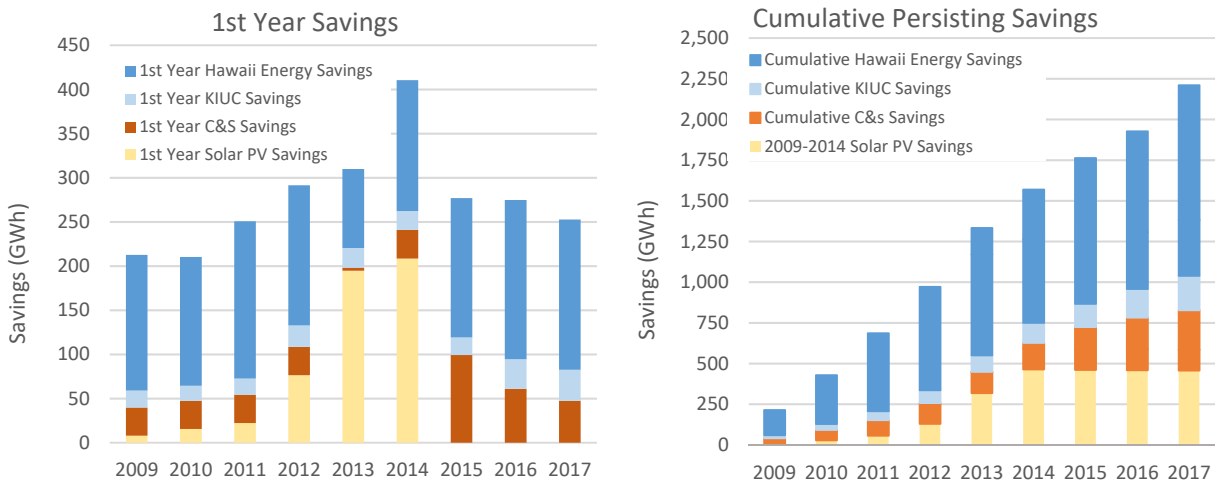
[34] kW assumed to be the lower of the panel STC kW or inverter kW.

[35] Assumes an annual degradation factor of 0.005.

[36] Savings in new construction from building codes is estimated by assuming a building turnover using a 60-year building life and estimating a 20% improvement in building efficiency as buildings are replaced. One third of building energy use is assumed to be plug loads not available for improvement through building codes. This estimate does not include an incremental savings for new buildings that do not replace existing buildings and is, thus, a conservative estimate. This methodology is used for estimating effects of building codes for years 2009 through 2012.

[37] Pursuant to HRS 269-91 customre-sited renewable generation is included in the RPS, and excluded from EEPS beginning on January 1, 2015. https://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.htm

Figure 4-1 Savings from Codes and Standards (2009-2017)



Future Savings Estimates

The updated potential analysis provides estimates of the 1st year (or incremental) and cumulative savings for the forecast period (2018-2030) as shown in Figure 4-2 and Figure 4-3 below. The savings represent:

- Savings from codes and standards already on the books. As noted above, these savings increase substantially in 2015 as a result of EISA Phase I. In 2020, these savings increase dramatically again as a result of the second EISA Phase. The analysis did not consider any additional codes and standards that have not been approved by DOE, Congress or the State of Hawaii.
- Ongoing programs savings under a business-as-usual ("BAU") scenario. These savings were estimated by assuming customer participation rates that are similar to those we estimated to account for savings achieved during the 2013 through 2017 time period. The BAU program savings level off after 2020 as a result of reduced savings from lighting. BAU lighting savings decrease because a portion of the savings will be attributed to codes and standards instead of programs as a result of EISA Phase II, which takes effect in 2020. . Ongoing program savings reflect the entire state and include estimated savings for both Hawaii Energy and KIUC.

Figure 4-2 1st year Savings from All Sources 2009 to 2030

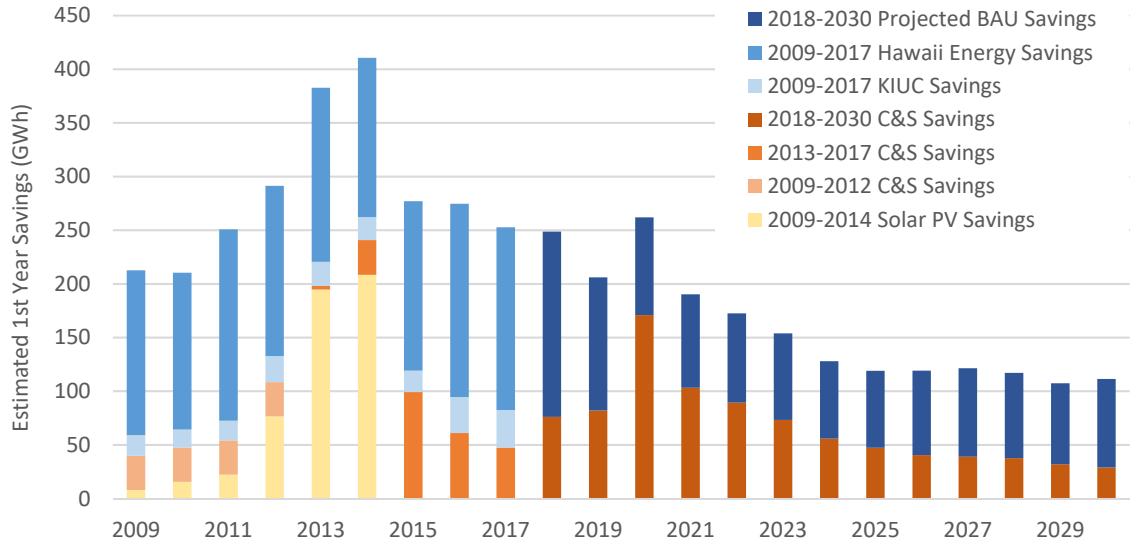
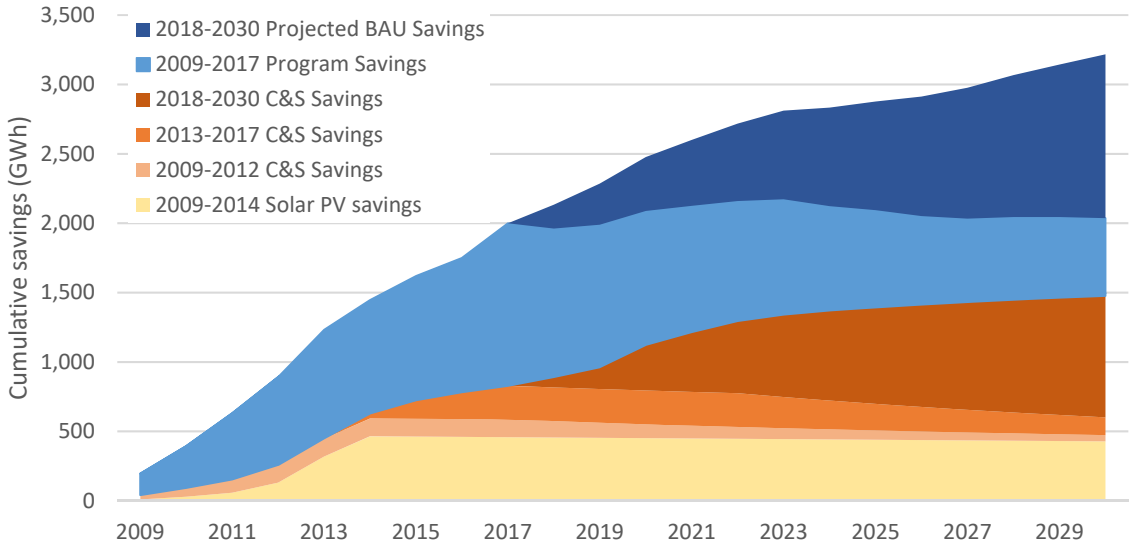


Figure 4-3 Cumulative Persisting Savings from 2009 to 2030[38]



Sector-level Results

The Potential Study Phase I analyzed the residential and commercial sectors individually and results for the residential and commercial sectors are presented below: historical 1st year savings, future 1st year savings, and future cumulative persisting savings.

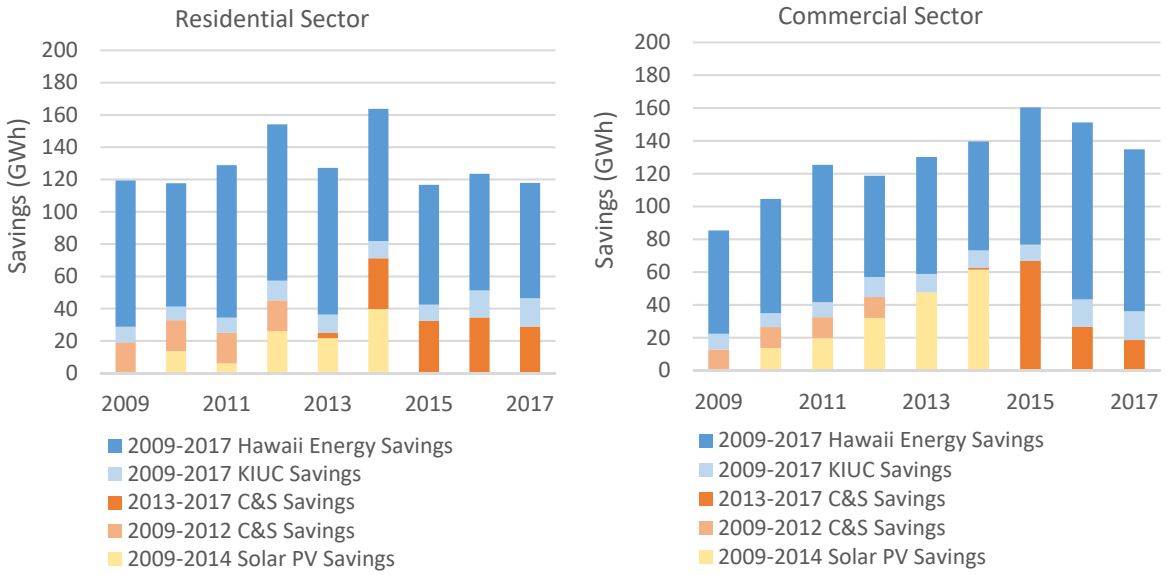
[38] KIUC Savings were not included in the cumulative view because insufficient information was available to assume a degradation rate for savings in future years.

Historical Savings

As mentioned above, the first step was to align the models with actual sales for the historical period (2013-2017) and also to estimate the savings from codes and standards during that time frame. Figure 4-4 shows the estimates of 1st year savings from codes and standards in the context of all historical savings from 2009 through 2017. The EISA lighting standard that went into effect in 2014 is a primary driver of these savings.

Another important point is that total annual savings for each sector over this time period are similar. The 1st year residential savings average was 75 GWh over this time horizon, while commercial 1st year savings average was 69 GWh.

Figure 4-4 Estimates of Historical 1st year Savings by Sector



Future 1st year Savings

In the forecast period, however, savings from the two sectors are expected to diverge. In Figure 4-5 below, we present the estimated savings from 2018 through 2030 by sector. Considering only savings from codes and standards and BAU Hawaii Energy Programs and KIUC Programs (identified BAU Savings in the figure below), more savings are expected to occur in the commercial sector through 2023. After 2023 savings from the commercial sector decrease and dip below residential savings beginning in 2024.

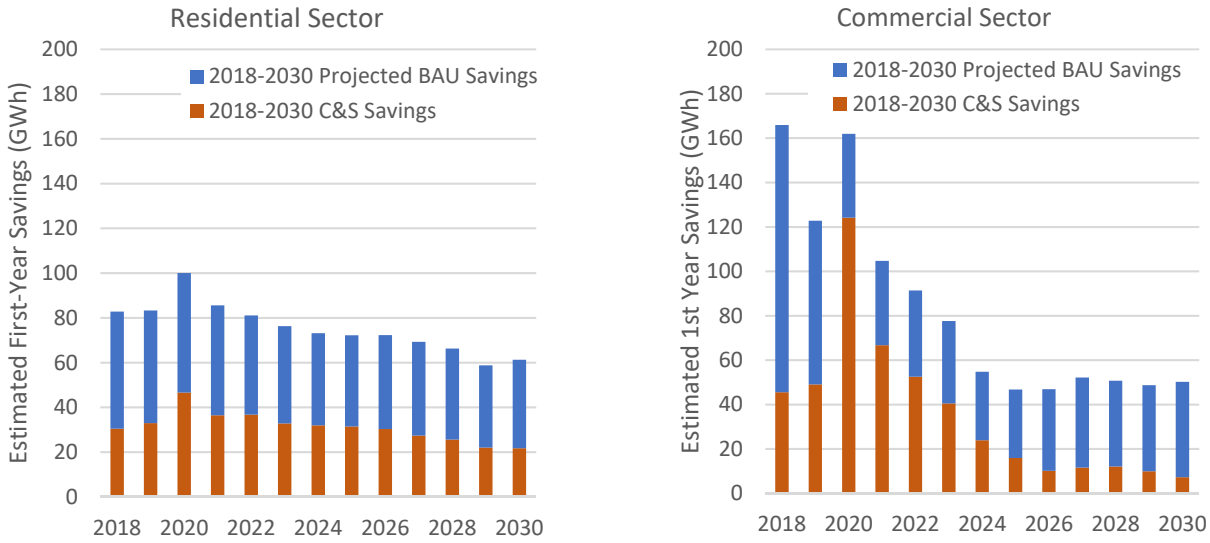
Codes and standards savings are expected to come from the following:

- In the residential sector, Phase II of the EISA standard that goes into effect in 2020, generating lighting savings. There are also savings from set-top boxes/DVRs, central air conditioners, water heating (both heat pumps and solar water heating code in new construction), and appliances.
- In the commercial sector, savings result from replacement of T12 lamps with T8s, the NEMA premium non-HVAC motor standard and from a walk-in refrigerator standard.

BAU savings for 2018 through 2030 were modeled as an extension of previous years, after aligning with actual sales and past program accomplishments[39]. Lighting accounts for a large portion of 2018 savings.

[39] Please note that these are estimates of energy efficiency potential and were developed independently. These estimates do not reflect information from Hawaii Energy regarding expected savings for PY2018 or for future years.

Figure 4-5 Estimates of Future 1st year Savings from Codes and Standards and BAU Programs



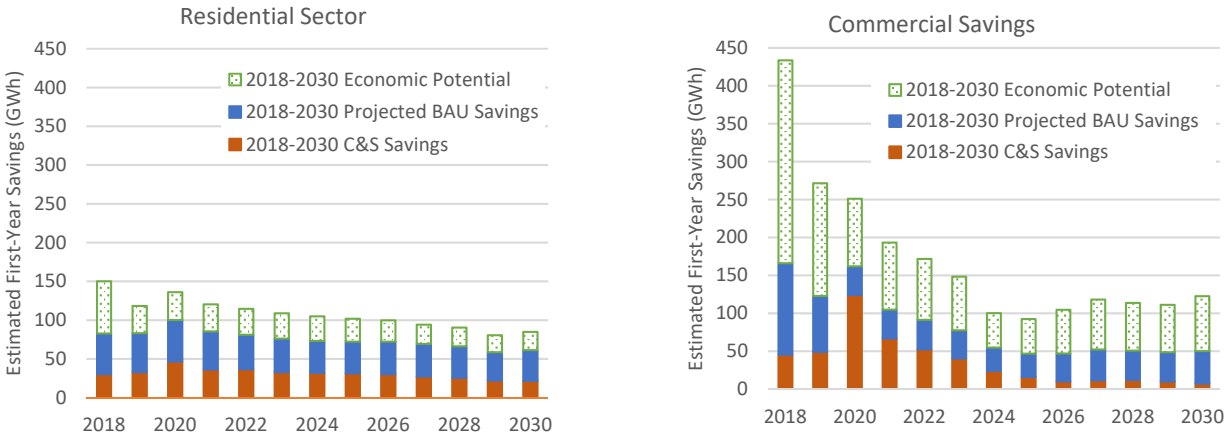
Adding economic potential, as shown Figure 4-6, shows even more potential for the commercial sector relative to the residential sector. In the commercial sector, program savings, for both BAU and economic potential, are expected to come from the following:

- High-efficiency chiller, rooftop package units and packaged terminal air conditioner (PTAC) units
- Variable air volume systems for all central cooling systems
- Heat pump water heaters
- Lighting savings from upgrading linear lamps and troffers and high bay fixtures to LED options
- High-efficiency refrigeration systems
- Energy Star food preparation equipment and office equipment
- High efficiency pool equipment, including variable speed pool pumps
- Energy management systems
- Sensors for room occupancy can provide savings for lighting, HVAC, and office equipment
- Daylighting controls
- Highly reflective roofs and well insulated ducting

In the residential sector, program savings may come from the following end uses:

- Water heating: conversion to solar water heating and heat pump water heating in existing homes, pipe insulation, low-flow showerheads, and faucet aerators
- Cooling: window reflective film, programmable thermostats and home-energy management systems,
- Appliances: refrigerator and freezer early replacement and recycling for obsolete units
- Lighting: occupancy sensors for interior lighting and photosensors for exterior lighting

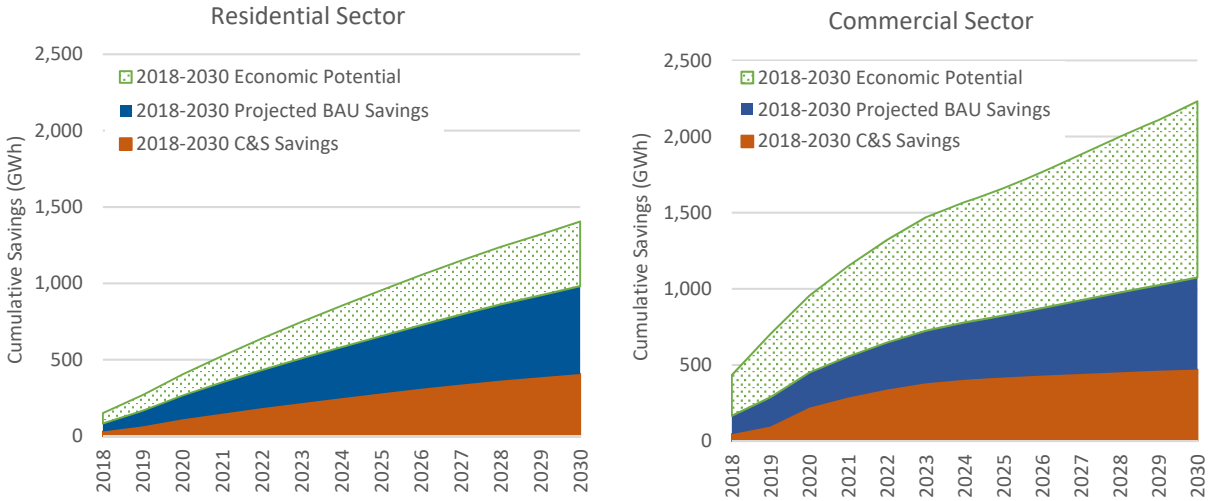
Figure 4-6 Estimates of Future 1st year Savings Including Economic Potential



Future Cumulative Persisting Savings

We now look also at future cumulative persisting savings considering only savings from codes and standards, BAU Hawaii Energy Programs and KIUC Programs (identified BAU Savings in the Figure below), and economic potential. From this perspective, and considering economic potential, the commercial sector is expected to contribute more than the residential sector.

Figure 4-7 Estimates of Future Cumulative Persistent Savings Including Economic Potential



5

STATE PROGRESS TOWARD EEPS GOAL

The 2030 EEPS goal was expected to be achieved by a combination of work by Hawaii Energy as well as other contributing entities, including:

- Kauai Island Utility Cooperative implements its own efficiency program for its customers. It is both a regulated entity and a contributing entity. [40]
- US Department of Defense is subject to federal Energy Independence and Security Act energy efficiency targets, which require a 30% energy use reduction by 2025.
- Hawaii State Government has a goal of 30% electricity use reduction by 2030.
- Codes and standards savings are attributable to federal and state appliance standards and building codes.
- Customer-Sited Solar Photovoltaic ("PV") savings are 1st year savings prior to 2015 for PV systems installed before 2015. These savings were significant contributors and are estimated based on Hawaiian Electric Companies (HECO) data.[41]

Collectively, other contributing entities in the State play an important role in the statewide achievement of EEPS. While the Department of Defense and State Government agencies are not subject to oversight by the Commission,[42] Hawaii Energy has been actively coordinating with most non-regulated contributing entities. As a result, most of the savings from other contributing entities -- except for KIUC, solar PV installed before 2015, and codes and standards -- are captured through the Hawaii Energy Program and therefore are not reported separately in the table and figure below to avoid double counting.

Table 5-1 and accompanying Figure 5-1 present 1st year savings for the First EEPS Reporting Period, plus 2016 and 2017. Hawaii Energy savings have been verified by a third-party evaluator. The estimates of the effect of codes and standards (which account for most of the "non-regulated entity" savings) is less certain given lack of data on current construction practices and purchase decisions and evidence of what energy consumption would have been in the absence of codes and standards.

Hawaii has consistently exceeded the EEPS interim annual savings goals in terms of 1st year savings during the first nine years of the EEPS program. Hawaii Energy accounted for 80% of the EEPS interim goal and just over half of all total EEPS Program 1st year savings contributions during the First EEPS Performance Period. It is expected that Hawaii Energy will continue to provide the bulk of the energy savings in the Second EEPS Performance Period (2015-2020). However, codes and standards will provide an increasingly

[40] In savings tables and figures, note that pursuant to HRS § 269-91, under the definition of "Renewable electrical energy," energy efficiency technologies include heat pump water heating, ice storage, ratepayer-funded energy efficiency programs, and use of rejected heat from co-generation and combined heat and power systems, excluding fossil-fueled qualifying facilities that sell electricity to electric utility companies and central station power projects.

[41] The success of the net energy metering program for customer PV installations is seen in 2013 and 2014, where first year impacts from PV installations well exceed Hawaii Energy portfolio first year impacts. Per HRS §269-91: "…beginning January 1, 2015, electrical energy savings shall not include customer-sited, grid-connected renewable-energy systems." After 2014, customer PV installations no longer count towards the EEPS goal, so PV values drop to zero on a 1st year savings basis but do provide ongoing savings that can be counted toward achievement of the EEPS goal.

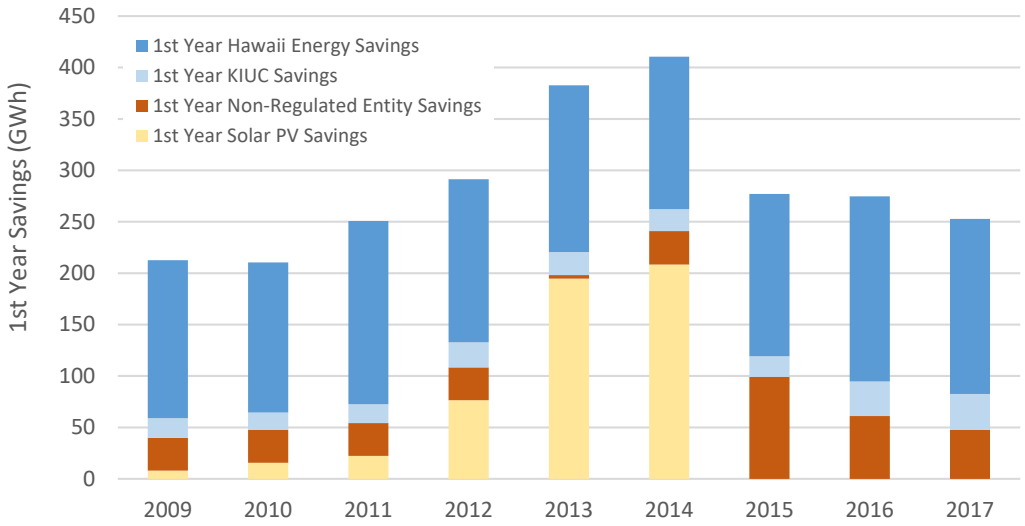
[42] In recognition of this reporting challenge, the EEPS Framework considered explicit energy efficiency goals for all entities contributing to achievement of EEPS, including measurement and reporting of energy savings to the Commission. The Commission, however, elected in consultation with the TWG not to pursue this approach.

significant contribution toward EEPS savings. Hawaii also has opportunities to further increase these savings through local codes and standards development and adoption. Coordination with other non-regulated entities will continue to be important for maximization of contributions toward EEPS goals.

Table 5-1 Statewide 1st Year Savings Compared to Annual EEPS Goal[43]

Program Year	System Level Hawaii Energy Savings	KIUC Savings	Non-Regulated Entity Savings	Solar PV Savings prior to 2015[44]	*Total 1st Year Savings*
2009	153.8	19.2	31.9	7.9	*212.6*
2010	146.6	16.9	31.9	15.6	*211.0*
2011	178.3	18.3	31.9	22.3	*250.8*
2012	158.5	24.4	31.9	76.5	*291.3*
2013	162.2	22.4	3.4	194.7	*382.7*
2014	148.4	21.4	32.7	208.4	*410.9*
2015	157.8	20.0	100.1	0	*277.9*
Subtotal	**1,105.6**	**142.5**	**264.3**	**525.4**	***2,037.8***
2016	180.1	33.6	61.9	0	*275.6*
2017 Reported	170.2	35.0	48.3	0	*253.5*
Total	**1,456**	**211**	**375**	**525**	***2,567***

Figure 5-1 Estimates of 1st Year EEPS Savings



[43] Note that program years don not align with the annual goals on a calendar basis. Program years run from July through June, while calendar years run from January through December. However, given that the annual goals are straight line goals, the comparison is appropriate given that both the program year and the annual goal cover twelve months. In 2030, an additional true-up will be required to capture savings that occurred in the last half of calendar year 2030 but would not have been included in PY2029 savings.

[44] For 2009, solar PV savings estimates are from HECO's Net Energy Metering Status Report to the PUC. For 2010–2014, solar PV savings are from HECO customer account level data; cumulative installed kW capacity was multiplied by monthly capacity factors and adjusted to reflect annual degradation of PV production.

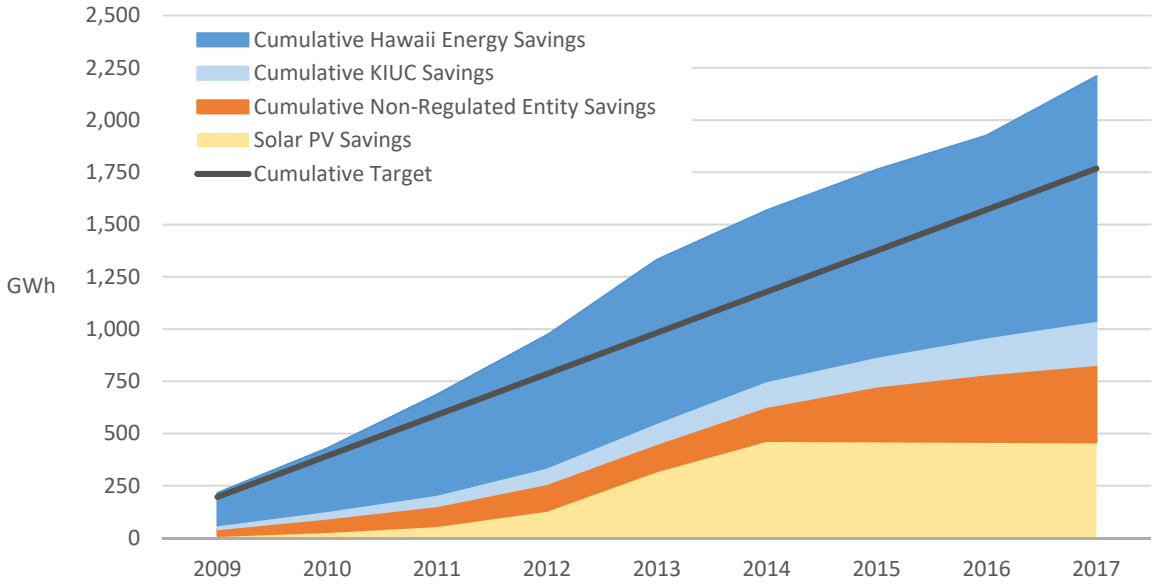
While the estimated savings for the state of Hawaii consistently exceed the EEPS Interim annual goal relative to 1st year savings, it is also important to look at cumulative persisting savings over time. 1st year savings account for the total savings achieved in the first year an efficiency measure is installed, while cumulative persisting savings represent the savings that persists over time considering the varying lifetimes of installed measures. For example, in 2010, the cumulative savings would include 1st year savings for 2010 and the persisting savings from 2009 for measures with useful lives longer than one year.

Table 5-2 and accompanying Figure 5-2 present the cumulative persisting savings from solar PV, programs, and codes and standards accounting for measure life and the degradation of savings over time.

Table 5-2 Statewide Cumulative Persisting Savings Compared to EEPS Goal

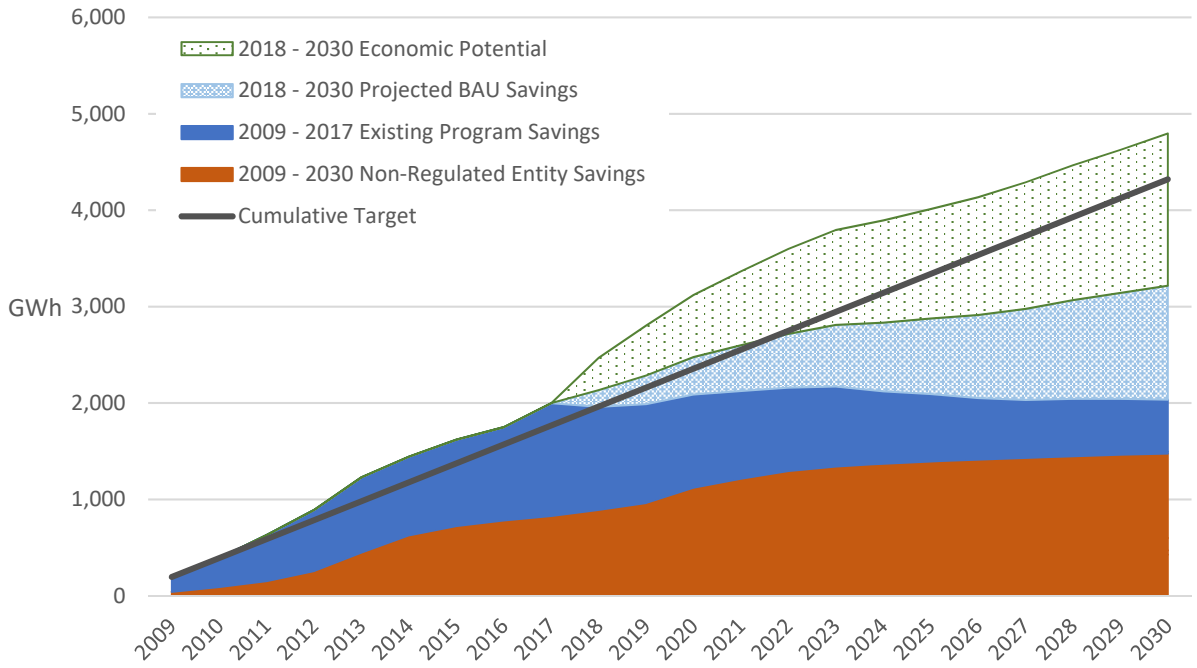
Program Year	System Level Hawaii Energy Savings	KIUC Savings	Non-Regulated Entity Savings	Solar PV Savings prior to 2015	*Total Cumulative Persisting Savings*
2009	153.6	19.2	31.9	7.9	*212.6*
2010	299.6	36.1	63.8	23.5	*423.0*
2011	477.8	54.4	95.7	45.8	*673.7*
2012	633.7	78.8	127.6	122.3	*962.4*
2013	781.4	101.2	131.0	317.0	*1,330.6*
2014	817.7	122.6	163.7	525.4	*1,629.4*
2015	895.5	142.6	263.8	525.4	*1,827.3*
2016	966.6	176.2	325.7	525.4	*1,993.9*
2017 Reported	1,170.3	211.2	374.0	525.4	*2,280.9*

Figure 5-2 Statewide Cumulative Persisting Savings Compared to EEPS Goal



Based on this analysis, Hawaii appears to be on track to meet the Interim EEPS goal through 2020. In order to estimate how likely it might be that the State meets the EEPS goal in 2030, AEG also compared the overall cumulative persisting savings estimates to the EEPS goal of cumulative 4,300 GWh by 2030, which is shown below in Figure 5-3. From 2009 through 2017 cumulative persisting savings, like 1st year savings, exceed the EEPS goal. Similarly, the State appears to be on track until 2022 to exceed the EEPS cumulative current goal trendline. However, in 2023, there is a gap between the then cumulative current savings (BAU savings and the trend line). The analysis shows, however, that there are sufficient cost-effective savings (green area) available to reach the EEPS goal.

Figure 5-3 Estimate of Cumulative Savings Potential Compared to Cumulative Goal



The current EEPS Review process includes the development of a Baseline Study and an update of the 2014 Energy Efficiency Potential Study. These studies and other EEPS research can inform stakeholder discussion regarding how and to what degree the EEPS program should evolve to more broadly support the energy and environmental policy objectives of the State.

A

APPENDIX A – SAVINGS TERMINOLOGY & EXPLANATION OF DIFFERENCES

AEG identified several types of savings referenced throughout the various source documentation, including the Hawaii Energy Annual Reports, Verification reports, TRMs, and the 2014 Report to the Legislature. In addition, we identified several differences in how the metrics are reported in the previous Report to Legislature and across other public sources. First, we present a glossary of savings, then we document the differences we identified.

Glossary of Savings Terms

- Tracked. Tracked savings refers to the ex-ante savings estimates from the TRM that are reported by Hawaii Energy. With the exception of verified, tracked savings can refer to any of the other types of savings listed below.
- Verified. Verified savings refers to the savings numbers published in the Verification Report and represent tracked savings adjusted by the appropriate realization rate determined in the verification. Since these numbers represent the best available estimate of actual savings for each program year, the EEPS research focuses on verified savings. Like tracked savings, verified can refer to any of the additional types of savings listed below.
- Net. Net savings refer to savings that are net of free ridership and spillover the savings have been adjusted using a net to gross ("NTG") ratio.
- Gross. Gross savings refer to the unadjusted savings which do not account for free-ridership or spillover and have not been adjusted using an NTG ratio.

The next three types of savings are terms used within the industry, but they are also used with the specific definitions that follow by Hawaii Energy.

- Customer level savings (gross at the meter). This savings refers to the tracked savings unadjusted for free-ridership or spillover, and not accounting for transmission and distribution losses. This is the savings defined by the TRM.
- System level savings. (gross generated). This savings refers to the gross (unadjusted by NTG) savings realized at the utility system level and includes transmission and distribution losses. In Hawaii Energy reports prior to 2016, this was simply called gross level savings.
- Program level savings (net generated). This refers to the amount of reduction that can be directly attributed to the programs. It is the system level savings adjusted by the NTG ratio to account for free ridership and spillover.

Differences in Metrics Across Time and Sources

AEG identified the following differences in how savings are reported in various public sources during our research:

- The Verification Memos (with the exception of 2009) focus on net tracked and verified savings, meaning that the estimates have been adjusted to account for free-riders or spillover.
    - In 2009 only, the Verification Memo reported gross (unadjusted) tracked and verified savings

- The Hawaii Energy Annual reports focus exclusively on tracked savings. In addition, in 2016 they shifted to focus on Customer and Program level savings vs. system level savings.
- The 2014 Report to Legislature focused on verified system level savings (with the exception of demand savings). Therefore the numbers that were reported cannot be directly sourced to either the Hawaii Energy Annual reports or the Verification Memos. Verified System level savings can, however be calculated by applying the appropriate realization rate (from the Verification Memos) to the tracked system level savings in the Hawaii Energy Annual Reports.
- Demand savings were reported at the customer level in the 2014 Report to Legislature. In the AEG report and in the 2019 Report to Legislature demand savings were reported at the system level.
- AEG's analysis focused on Verified System Level Savings (unless otherwise noted) since that is the most appropriate for the EEPS framework.

B

APPENDIX B – OTHER CONTRIBUTING ENTITY DATA COLLECTION INSTRUMENTS

Below we include the email text that was sent to the other contributing entities, and the data collection procedures that AEG developed for the research.

Email Text

Aloha "Contact Name",

As you are likely aware, the State of Hawai'i is aiming for 100% renewable energy in the electricity sector by 2045. In addition to renewable generation, energy efficiency savings play a large part in meeting these goals. To that end, the Hawai'i State Legislature established an Energy Efficiency Portfolio Standard (EEPS) which mandates a 4,300-gigawatt-hour reduction in electricity use by 2030. Every five years, the Commission publishes a progress report which measures the total energy efficiency savings in the state and assesses the progress toward that goal.

For more information on EEPS Reporting, please see our previous report here: http://www.hawaiicleanenergyinitiative.org/wp-content/uploads/2017/03/EE-Charrette_PUC_2014_Rpt.pdf

As part of the measurement of energy efficiency savings for the 2019 EEPS Report to the State Legislature, the Hawai'i Public Utilities Commission is reaching out to selected entities to request information on energy efficiency related activities and actions which may count toward meeting state goals. To facilitate this effort, we would like to put your energy manager, facilities manager, or other qualified decision makers in contact with Applied Energy Group (the PUC's Evaluation Measurement and Verification contractor) to discuss energy efficiency with respect to your operations as part of the United States Armed Forces. Please expect an AEG representative to follow up with you within two business days to schedule a 30-minute interview.

Your input is incredibly valuable to this process and we thank you for continuing to support the Commission and the state of Hawai'i in our quest for energy independence.

Mahalo,

Data Collection Procedure

The following steps will be taken to collect information on energy efficiency related activities and actions which may count toward meeting state EEPs goals.

1. Email outreach sent by PUC to list of non-regulated entities. AEG is copied on each email.
2. AEG will reply to each email, introduce ourselves and ask to schedule a telephone interview.
    a. If necessary, a second reminder email will be sent.
    b. If necessary, the second email will be followed with a telephone call requesting an interview.
3. Schedule Interview

4. During each interview AEG will do the following:
    a. Briefly restate the goal of the interview.
    b. Ask if any energy saving projects have been completed since 2014
        i. If yes, ask if these projects were part of a Hawaii Energy program (e.g., received rebates, incentives, etc. from Hawaii Energy)
        ii. Prompt for the following:
            1. Replacement/upgrades of equipment
            2. Purchased new energy use equipment
            3. Lighting retrofits
            4. Purchased/replaced automated controls or devices
            5. Made any changes/improvements to the building shell
            6. Implemented any behavioral programs (e.g., encouraging employees to turn off lights and electronics when not in use)
            7. Installed solar or other renewable energy
            8. Purchased or leased batteries
        iii. Request data or information on the projects and any energy saving estimates.
    c. Thank them for their time and cooperation. Ask if it's okay to follow up if necessary.
    d. Follow up to collect data/information if necessary.
    e. Follow up to clarify data/information if necessary.

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